National Center “Junior Academy of Sciences of Ukraine” under the auspices of UNESCO

OBTAINING CADMIUM SULPHIDE FILMS BY CHEMICAL DEPOSITION

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The aim and relevance of the work

The aim of this work is to carry out the obtaining of cadmium sulfide films through chemical deposition and to analyze them on laboratory instruments. .

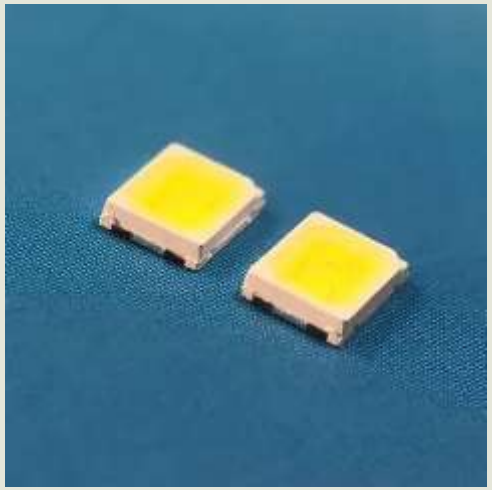
Used methods:

- Chemical deposition method.
- X-ray diffraction method
- Optical spectroscopy method
- Gravimetric method for thickness measurement

The relevance of this work lies in the cost reduction of electronic device production that utilizes CdS, by means of a simple synthesis of thin films of CdS by the chemical deposition method.

The subject of the study is CdS in film form and chemical deposition

Cadmium sulfide, its properties, and application areas



Cadmium sulfide is a binary, inorganic compound that is a yellow and solid under normal conditions.

This compound is used in such areas as:

1. Dye – also known as cadmium yellow. As of 1982, about 2,000 tons of yellow pigment were produced annually.
2. Luminophores – especially effective in electroluminescence.
3. Nanotechnology – used in solar cells, optoelectronics, lasers, LEDs, QD-LED displays, etc.
4. Medicine and biology – used as luminescent labels.

Method of chemical deposition of CdS films

The initial reagents for the chemical deposition of CdS films are:

1. Cadmium salt
2. A complexing reagent,
3. A chalcogenizing (sulfur-containing) reagent,
4. A pH regulator if necessary, when the working solution medium is not sufficiently alkaline

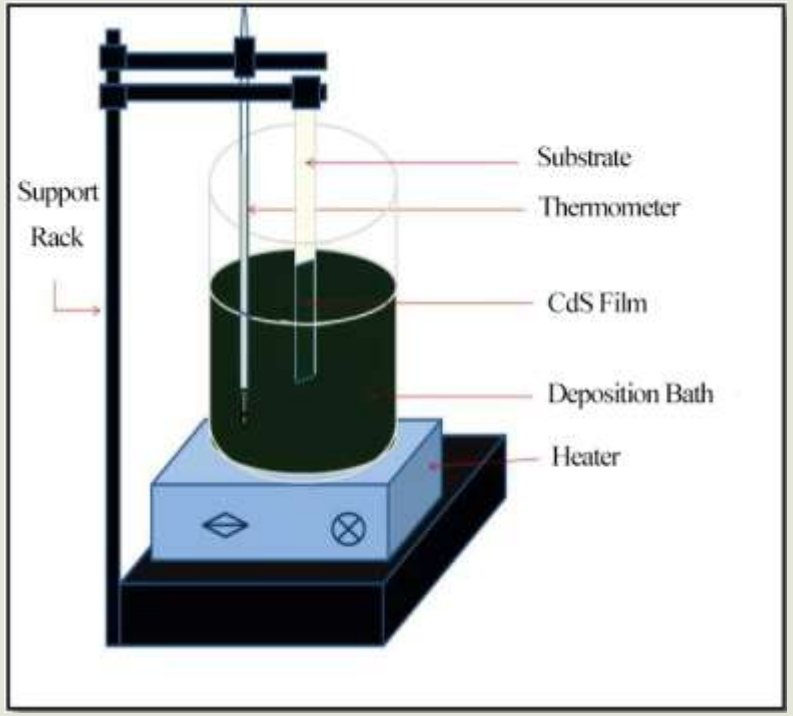


Figure 1 – Laboratory installation for the CdS films synthesis.

According to the literature, the chemical deposition process includes the following stages:

1) the interaction of cadmium ions and a complexing reagent, with the formation of complex ions, which reduces the overall reaction rate and prevents the formation of undesirable products ($Cd(OH)_2$, CdO):

$$Cd^{2+} + xL^{n-} \rightarrow CdL_x^{2-xn}$$

Ln- – ions of the complexing reagent).

2) hydrolysis of the chalcogenizing reagent:

$$R\text{-}S + OH^- \rightarrow S^{2-} + H_2O + P$$

R-S – chalcogenizing (sulfurizing) reagent,
P – products.

3) decomposition of complex metal ions during heating with the formation of the final product - insoluble cadmium sulfide:

$$CdL_x^{2-xn} + S^{2-} \rightarrow CdS\downarrow + xL^{n-}$$

Experimental preparation of CdS films by chemical deposition

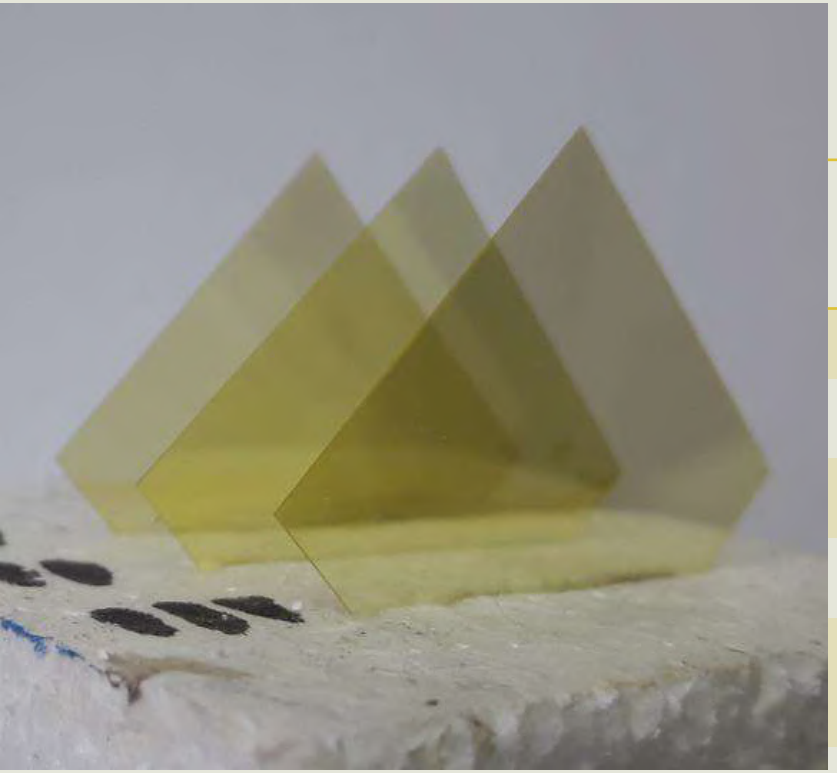
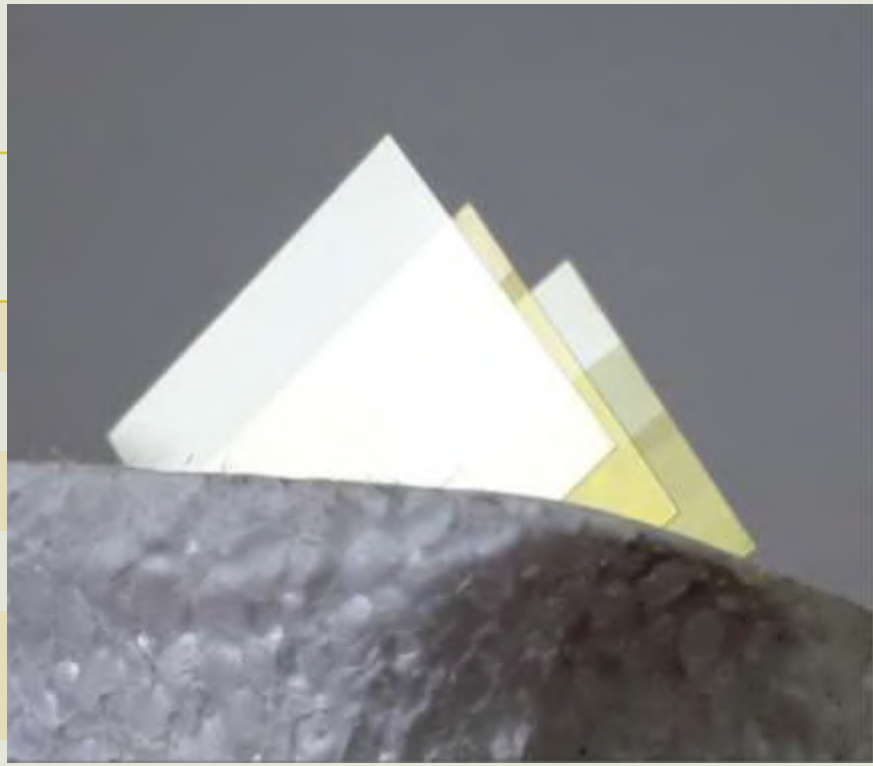


Table 1. Conditions for the synthesis of CdS films using trisodium citrate and ammonia.

Parameter	Value
$C(CdI_2)$, mol/L	0,005
$C(Na_3C_6H_5O_7)$, mol/L	0,2
$C(CS(NH_2)_2)$, mol/L	0,05
$C(NH_4OH)$, mol/L	0,14
Deposition duration, min	60
Temperature, °C	60



Pic. 2 Samples of CdS films chemically deposited on glass substrates

Experimental preparation of CdS films by chemical deposition

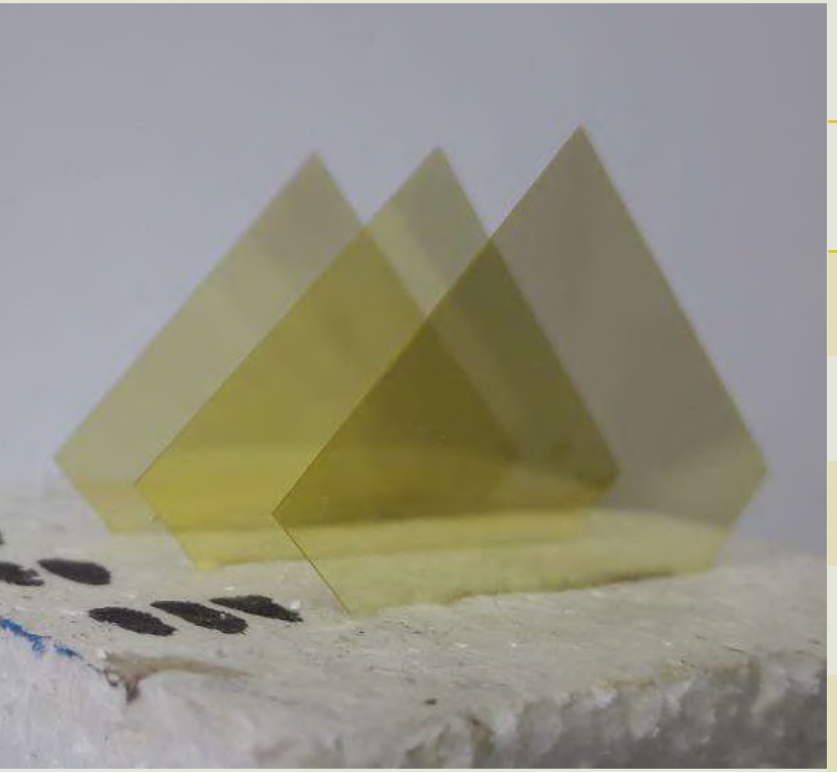


Table 2. Conditions for the synthesis of CdS films using triethanolamine.

Parameter	Value
$C(CdI_2)$, mol/L	0,005
$C(N(CH_2CH_2OH)_3)$, mol/L	1,0
$C(CS(NH_2)_2)$, mol/L	0,05
Deposition duration, min	20-40
Temperature, °C	60

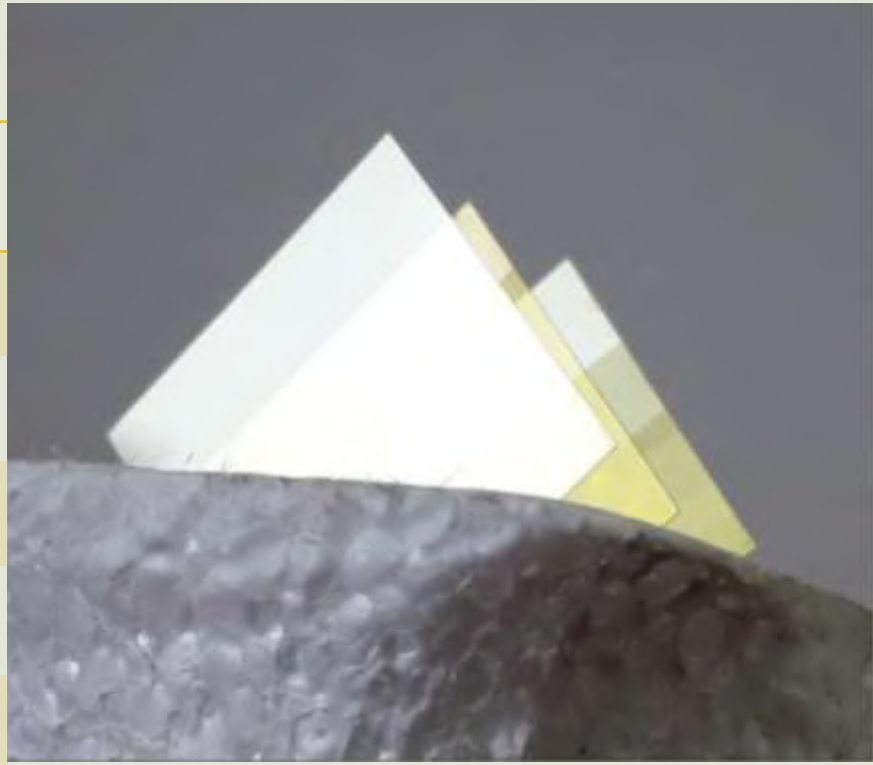


Figure 2 - Samples of CdS films chemically deposited on glass substrates

Results of analysis of CDS films on laboratory equipment

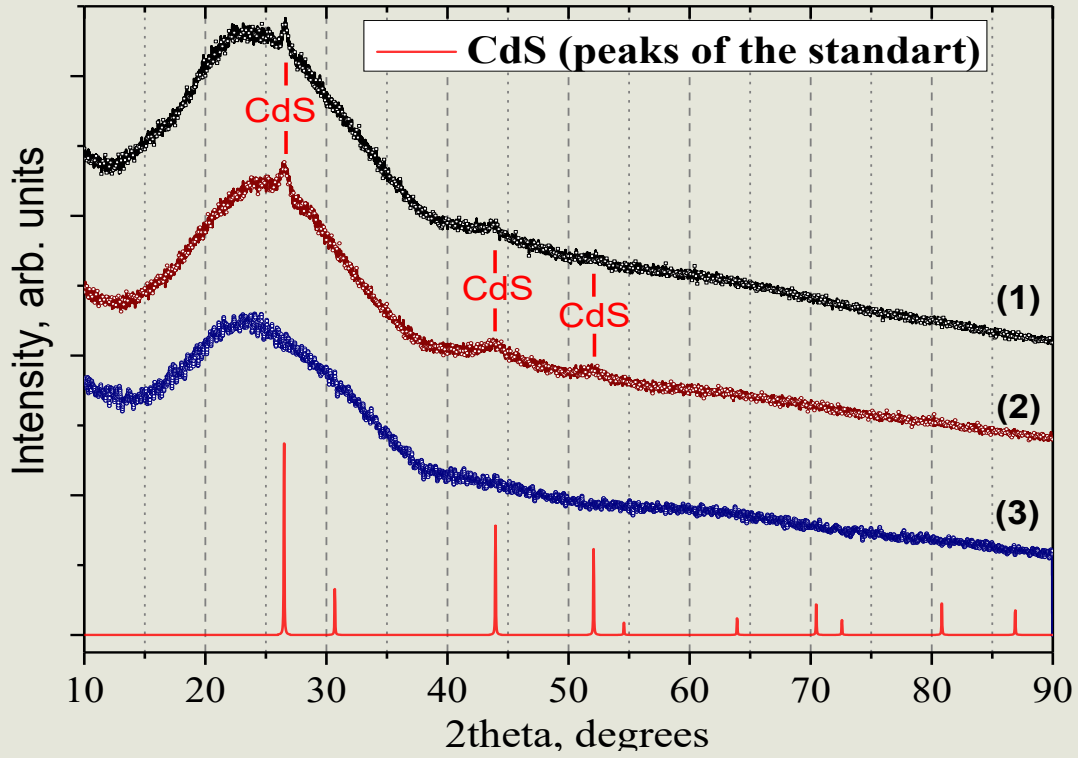


Figure 3 - X-ray diffraction patterns of CdS film samples on glass substrate obtained using trisodium citrate and ammonia (1), obtained using triethanolamine (2), and the glass substrate itself (3) for comparison.

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Results of analysis of CDS films on laboratory equipment

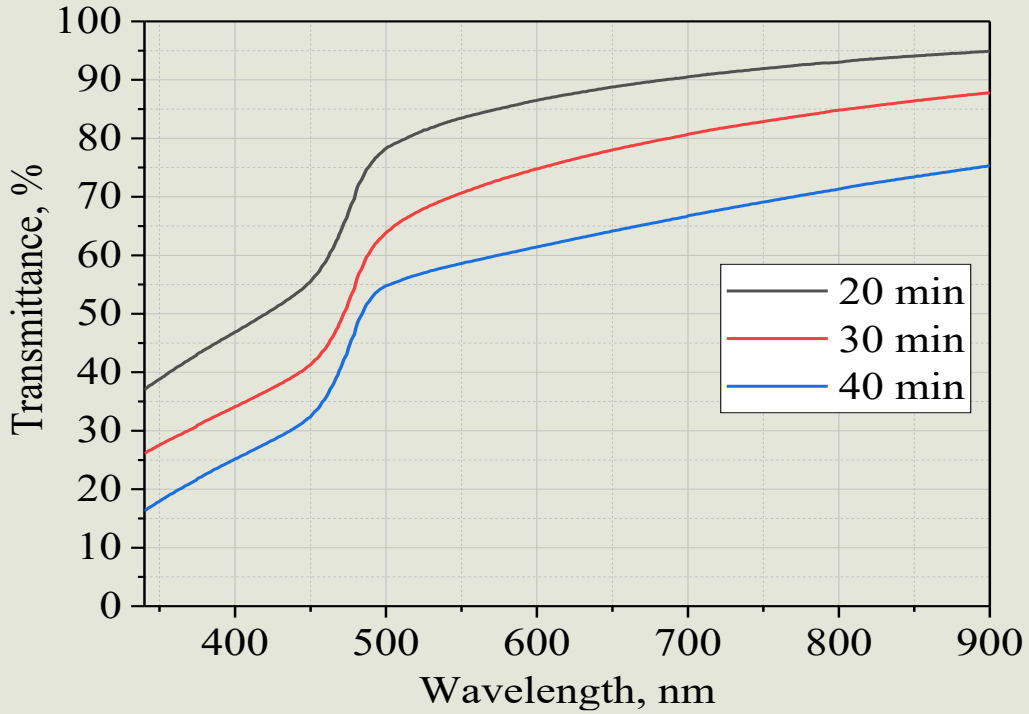

Figure 4 - Spectra of the optical transmittance of CdS films deposited using trisodium citrate and ammonia at different durations.

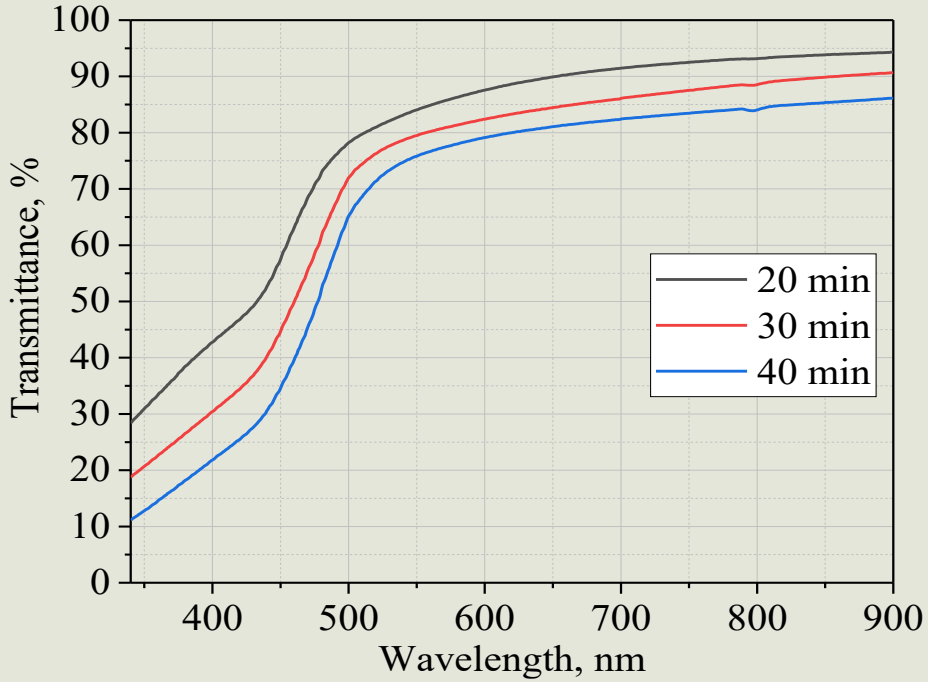

Figure 5 - Spectra of the optical transmittance of CdS films deposited using triethanolamine at different durations.

The average thickness of the CdS films

$$d = \frac{m_2 - m_1}{S \cdot \rho} = \frac{\Delta m}{S \cdot \rho} \text{ [cm]}$$

Where m_1 is the mass of glass substrates without CdS films (g); m_2 is the mass of glass substrates with CdS films (g); Δm is the mass of deposited CdS films (g); S is the area of the substrate surface (cm^2); ρ is the density of CdS (ρ = 4.826 g/cm^3).

The results of the measurements of the mass of CdS films deposited using trisodium citrate and ammonia			The results of the measurements of the mass of CdS films deposited using triethanolamine		
m_1, g	m_2, g	Δm, g	m_1, g	m_2, g	Δm, g
2,6471±0,0001	2,6504±0,0001	0,0033±0,0002	2,6338±0,0001	2,6380±0,0001	0,0042±0,0002

The result of the calculation of the average thickness of CdS films.

For CdS films deposited using trisodium citrate and ammonia:

$$d = \frac{0{,}0033 \pm 0{,}0002}{115{,}2 \cdot 4{,}826} = (5{,}94 \pm 0{,}36) \cdot 10^{-6} \text{см}$$ cm or 59.4±3.6 nm

For CdS films deposited using triethanolamine:

$$d = \frac{0{,}0042 \pm 0{,}0002}{115{,}2 \cdot 4{,}826} = (7{,}55 \pm 0{,}36) \cdot 10^{-6}$$cm or 75.5±3.6 nm

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CONCLUSIONS

1. The compound CdS, its physical, chemical properties, and applications have been considered.

2. A brief description of the method of obtaining cadmium sulfide (CdS) films by means of a simple and inexpensive chemical deposition method has been provided. Reaction schemes that occur during the synthesis of CdS films have been discussed.

3. Chemical deposition of CdS films was experimentally carried out using two reaction mixtures containing:

   cadmium salt - cadmium iodide CdI2, complexing agent - trisodium citrate, halogenating (sulfurizing) agent - thiourea (CS(NH2)2).

   cadmium salt - cadmium iodide CdI2, complexing agent - trisodium citrate Na3C6H5O7, halogenating (sulfurizing) agent - thiourea (CS(NH2)2) and pH regulator - ammonium hydroxide (NH4OH).

4. CdS films were investigated using X-ray diffractometer and optical spectrophotometer.

5. The average thickness of the CdS films was calculated from the measured mass using analytical balances.

In the future, additional research on CdS films can be carried out using different scientific equipment.

Thanks for your attention