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The optical properties of PbS and PbS/Ag thin films

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The chemical bath deposition approach was used to arrange PbS and PbS coated with Ag thin layer thin films. PbS film was deposited at room temperature using thiourea and lead chloride as precursors. After the PbS film had been deposited, it was immersed in Ag precursors for 60 minutes at 50 C to coat its surface. In this study, we looked at absorbance in the 400-1000 nm range. The direct and indirect bandgaps were estimated using the Tauc method and yielded values between 1.3 and 1.45 eV. It resulted in increasing in bandgaps after coating with of Ag layer.

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1. Introduction

Nanostructured semiconductor materials have been developed over many decades, and their unique and distinctive characteristics have led to their employment in a wide range of applications. [1], PbS is one of these semiconductors.

For solar cell manufacturing, PbS thin film has received a lot of attention recently as one of the most important IV-VI group semiconductors [2]. It has a relatively large Bohr radius of roughly 18 nm and a narrow energy bandgap, which makes it ideal for a wide range of applications. Quantum confinement for electrons and holes is provided by PbS. [3,4].

PbS nanostructures are a hopeful material that is commonly used in many applications and technologies, including photocatalyst, photodetectors , gas sensors , and solar cells [5-9].

Many fabrication method have been used to deposit PbS thin films, including solid vapor deposition [10], chemical bath deposition (CBD) [11], spray coated [12] , spin-coating [13], and electrodeposition [14] silver (Ag) was used as a coating for many semiconductors like CdS thin films [15], CdSe [16], and PbS [17] to reduce the health risk and toxicity of this material, which have no undesirable effects on humans

Based on our prior research into CdS/Ag hybrid thin film optical qualities, we've worked to uncover the mechanism between the Ag layer and the PbS hybrid in the current manuscript, which we're submitting for publication here. Comparing optical properties of CdS film before and after Ag layer deposition were studied, emphasizing the significant reduction in energy gap as well as an increase in absorption.

2. Experimental

Thin PbS and PbS/Ag films were created on a glass substrates with the help of CBD method. The following reactive compounds are present in the Pb solution. In a 100 mL beaker, combine the following ingredients: lead nitrate, sodium hydroxide, thiourea, and distilled water. For 20 hours, the bath was kept at a constant 25 °C. The thin film was made by dipping a clean substrate in the solution. This was followed by drying the PbS film overnight before dipping it in a silver-ion solution composed of silver nitrate (AgNO3), trisodium citrate, and deionized water in a

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100-mL beaker. For one hour, the bath was kept at a constant temperature of 50 degrees Celsius, which was monitored. However, once the Ag layer was deposited, the hue of the deposited film became shinny, indicating that the film had been homogeneously thickened and adhered well to its substrate.

3. Results and discussions

In order to investigate the size and morphology of particles in a PbS thin film, a Field Emission Scanning Electron Microscope (FESEM) was employed. Image of the PbS thin-film obtained by FESEM is depicted in Fig. 1.Stone shape particles well covered the film surface. The film shows no cracks or holes. The PbS nanostones are coalescent to form a continuous layer of multi-shape nano-stones , thier distribution on the surface is uniform . These nanostones have a arbitrary distribution with unequal sizes and shapes and that gave the rough surface[18,19].

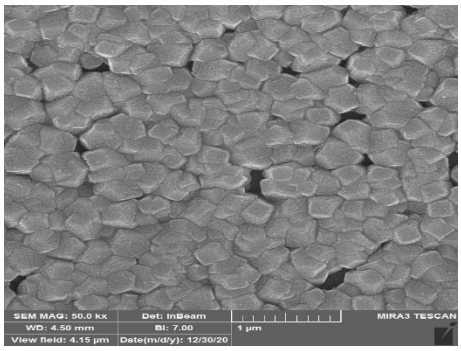

Fig. 1. PbS thin film FE-SEM micrograph.

Fig. 2 demonstrations the XRD pattern of PbS film. As can be seen, the presented film was well-match with the cubic structure of PbS (JCPDS No. 05–0592). Five distinguishing peaks 2 θ = 25.8°, 2θ = 30 ° and 2 θ = 43 °, 2 θ = 51 ° equivalent to Miller indices (111), (200), (220) and (311) respectively are perceived for the PbS film. [20-22].

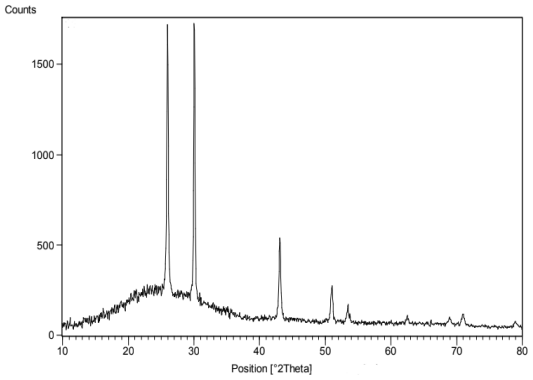

Fig. 2. PbS thin-film X-ray diffraction pattern.

Absorption measurements were made for PbS, and PbS coated with a thin layer of Ag between 400 and 1000 nm at room temperature. Two significant observations should be noted.

First: The edges absorption for PbS and PbS/Ag shift to lower wavelengths with respect to the bulk PbS. Second: The absorption edge of PbS/Ag thin film is also blue-shifted compared to PbS thin film [23].

As shown in Fig. 3, the absorption spectra of the PbS film exhibit a considerable absorption in the infrared region, but for the PbS/Ag film, a significant blue shift ing and a new peak at 600 nm have been seen, respectively.

The direct bandgaps of PbS and PbS/Ag films were detrmined by use of Tauc relation, as exposed in Fig. 4. The pure PbS film own a bandgap equal to 1.3 eV, and this result is comparable with results collected in ref [24,25] , which raised to 1.45 eV after the deposition of an silver layer on the top of PbS film.

Optical tests exposed the presence of indirect transition also. The indirect band gaps of PbS and PbS/Ag films are illustrated in figure 5. It had been observed that the indirect band gaps of PbS and PbS/Ag were 1.2 eV and 1.25 eV, respectively.

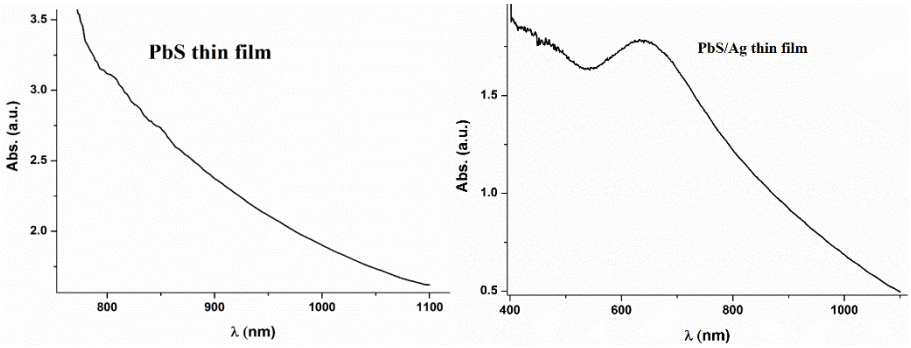

Fig. 3. The spectrum of absorption of PbS and PbS coated with Ag films.

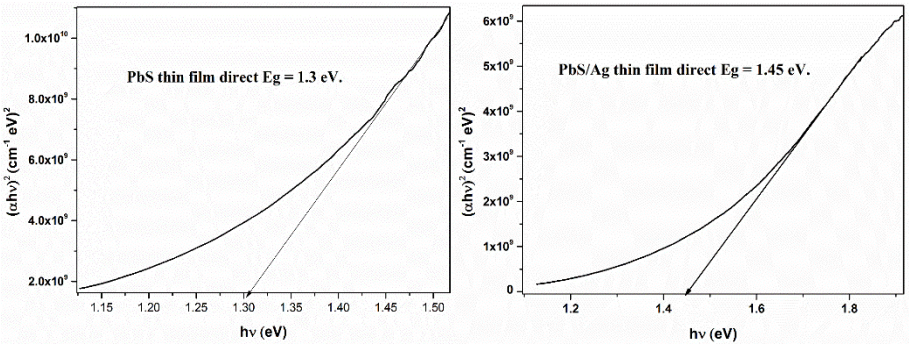

Fig. 4. Direct Band gaps of PbS and PbS coated with Ag films.

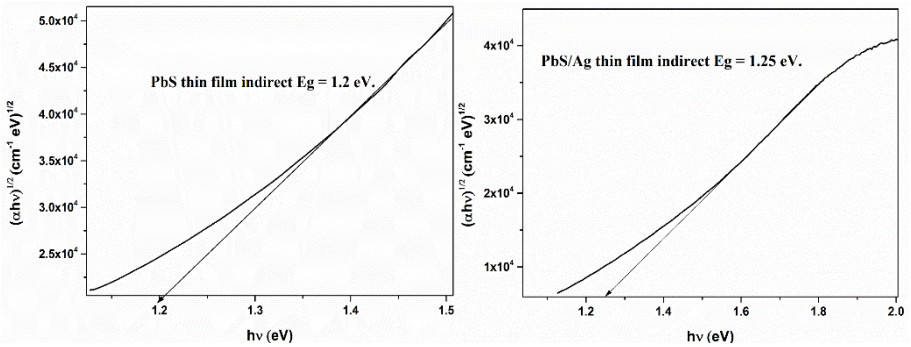

Fig. 5. Indirect Band gaps of PbS and PbS coated with Ag films.

4. Conclusion

For the deposition of nanocrystalline PbS and PbS/Ag thin films, the CBD approach was adopted in this study. The films demonstrated a high level of adhesion to the surfaces of their respective substrates. All of the XRD peaks were discovered to be related with lead sulfate. the influence of an Ag layer on the optical properties and the amount of direct and indirect bandgaps of PbS thin film have been examined.

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