Studies on Optical Properties on of Europium Chalcogenide thin Films

M. M. Betkar¹, A. N. Jadhav²
¹Shri Kumarswami Mahavidyalaya, Ausa, Dist. Latur,-413520, (MS), India.
²Yeshwant Mahavidyalaya, Nanded,-431602 (MS,) India.

ABSTRACT:
The optical studies on Europium Chalcogenide in particular Europium Sulphide (EuS) thin films have been carried out on non-conductive glass substrates in aqueous solution by spray pyrolysis technique at different substrate temperatures. The effect on optical properties has been investigated. The optical properties of films were studied by UV-Visible spectrometry. The effect of different substrate temperatures on energy band gap are reported.

KEY WORDS: Europium chalcogenide; band gap; EuS; spray pyrolysis;

1. INTRODUCTION:
The properties of the europium monochalcogenides EuO, EuS, EuSe and EuTe had have been studied as an initial hope of modern technological applications. The europium chalcogenides crystallize as sodium chloride in crystal structure. One of those, Europium sulphide (EuS) is a well known ferromagnetic semiconductor. [1-5]. Ferromagnetism has been found in several divalent europium compounds. Some of these materials are particularly simple in both crystal and magnetic structure and are ideal for experimental and theoretical study The materials can be divided into three groups, europium chalcogenides, europium halogens, and europium silicates. All the europium chalcogenide series have rocksalt structure, the oxide, sulphide, and selenide being ferromagnetic, on these materials the most work has been done.

The magnetic and electronic properties of europium chalcogenides have been studied widely [6-10]. The structural and optical properties of EuS in particular spray deposited EuS thin films have not studied so far. Several methods of the film deposition, such as vacuum evaporation (VE), chemical vapor deposition (CVD), chemical bath deposition (CBD), spray pyrolysis (SP), electrodeposition (ELD) etc have been employed for the deposition of thin films[11-12]. In the present work, spray pyrolysis deposition technique was successfully employed to prepare europium sulphide EuS thin films by simple and low cost chemical spray pyrolysis technique (CSP). The films have been characterized by UV-Visible spectrometry.

2. EXPERIMENTAL:
Europium Sulphide (EuS) thin films were deposited onto glass substrates from an aqueous solution bath containing Europium (III) chloride hexahydrate EuCl₃ (Sigma-Aldrich) and Thioacetamide CH₂CS.NH₂ . The precursor concentrations as 0.02 M and 0.002 M were prepared in deionised water in separate beakers in proportion 1:1. Aqueous solutions of EuCl₃ and CH₂CS.NH₂ were used as the sources of Eu and S, respectively. The EuCl₃ and CH₂CS.NH₂ solutions were mixed for 50 min, well mixed with magnetic stirrer at the rate 500 rotations per minute. The glass substrates were cleaned with dilute hydrochloric acid, standard laboratory detergent and also ultrasonically cleaned with double distilled water. The substrates were dried well before deposition. The deposition of the film was carried out at precursor at temperatures 275 °C, 300 °C, 325 °C and 350 °C. The deposition was carried out with spray pyrolysis technique (model No. Holmark HO-TH-04). The other parameters; carrier air pressure (27 psi), substrate to nozzle distance (15 cm), spray duration (2 min) and precursor quantity (2 ml/min) were kept constant throughout the experiment. The carrier gas was air. All the chemicals used were of analytical reagent grade (99% purity).

3. OPTICAL STUDY:
Optical transmittance measurements of the films were used to estimate the band gap energy from the position of the absorption coefficient edge. The absorption coefficient can be calculated using the relation:
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\[ \alpha = A \frac{h}{\nu} (h\nu - E_g)^{-1/2} \]

Where, A is a constant (slope) and \( E_g \) is the energy gap.

From the calculated values of the absorption coefficients a plot of \((\alpha h\nu)^2\) versus \( h\nu \) (Tauc’s plot), where \( \alpha \) is the optical absorption coefficient of the material and \( h\nu \) is the photon energy. Extrapolation of the plots to the \( x \)-axis gives the band gap energy of the EuS films deposited at 275 °C is shown in following Figure 1. The optical band gap energy of the EuS films deposited at 275 °C is found as 3.11 eV. This value is in good agreement with the value reported earlier. [13]

![Figure 1. Plot of \((\alpha h\nu)^2\) versus \( h\nu \) for spray deposited EuS thin films at 275 °C](image)

4. Conclusions:

The EuS thin films were successfully deposited on glass substrates at different substrate temperatures at precursor concentrations 0.002M and 0.02 M by spray pyrolysis technique. The Optical transmittance measurements indicate that the deposited films have a direct band gap of 3.11 eV. It is found that the precursor concentration moderately affects on optical properties of europium chalcogenide thin films.

References