

Structural and Optical Properties LaS Thin Films Prepared by Spray Pyrolysis Technique.

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ABSTRACT: Thin films of LaS were prepared by using spray pyrolysis technique at 300°C and thickness were varied by changing the concentration of reactant solution and thickness of prepared thin films on glass substrate was found to be 0.4632µm and 0.5307µm. The thin films were characterized by X-rays diffraction, optical absorption. The XRD studies reveal that the deposited, LaS thin films are polycrystalline. The optical absorption studies reveal that the material formed has direct band gap of 2.1eV and 2.4eV.

KEYWORDS: Spray Pyrolysis, LaS, thin films, Characterization, Band gap.

I. INTRODUCTION

Lanthanum sulphide is a binary semiconductor rare earth compound belonging to group III A – VI compound family. The thin films are rare earth metals having potential applications in magnetic, optical, nuclear, superconducting devices. [1-7].

Lanthanum Sulphide has many applications in rare earth alloy preparation, superconductivity, magnetic cooling, magnetic thin films, photovoltaic and thermo electric devices etc. Several research groups have prepared Lanthanum sulphide thin films with a number of physical and chemical techniques. Berkley et al [8,9].

However, no attempt has been made so far to prepare LaS thin films by spray pyrolysis which is quite simple, quick economical and suitable for large area deposition of any configuration and the growth can be easily be controlled through the spray rate, substrate temperature [10].

Many researchers [11-15] have reported, thickness of prepared LaS thin films on glass substrate varied by varying different deposition parameters.

Materials and Methods: LaCl₃, Thiourea of AR grade were used to prepare the LaS thin films of different thickness. Glass was used as the substrate. Before the deposition of the films, the glass substrate was clean by detergent, conc. H₂SO₄, double distillation water. The Chemical Spray Pyrolysis technique was used for the preparation of LaS thin films.

II. EXPERIMENTAL

The Lanthanum sulphide films were prepared onto cleaned glass substrates with optimized preparative parameters such as spray rate, substrate temperature, volume ratio, solution concentration [16]. Solution of Lanthanum trichloride (LaCl₃) and thiourea of AR grade were prepared in doubly distilled water and the films were prepared by using appropriate volumes of these solutions, to obtain La:S ratios of , 10:10, 15:15 ml. The resulting 20ml, 30 ml solution was sprayed onto preheated glass substrate. The spray rate was maintained at 2ml/min. The distance between substrate and nozzle was 28 cm [10]. The substrate temperature was kept at 300°C. When the sprayed droplets of the solution reached the hot substrate, pyrolytic decomposition occurred and yellow coloured films were formed. The films were allowed to cool to the room temperature. The thickness of the Lanthanum sulphide was found to be 0.4632µm and 0.5307 µm [16]. These films were optically characterized by using UV-visible spectrophotometer.

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III. CHARACTERIZATION

The thickness of the Lanthanum sulphide films were determined by weight difference method using following relation:

$$t = \frac{\Delta m}{\rho_s A} \quad \text{----- (1)}$$

Where A is the area of the deposited LaS films onto glass substrate, Δm is the mass of the deposited LaS films, ρ_s is the density of the LaS thin films material (4.98 gm.cm^{-3}) [9].

Optical absorption spectra of Lanthanum sulphide have been studied in the wavelength 380-1000 nm. The nature of the transition involved can be determined on the basis of the dependence of the absorption coefficient α on photon energy ' $h\nu$ '. For allowed direct transition ' α ' is given by

$$\alpha = K \frac{(h\nu - E_g)^{1/2}}{h\nu} \quad \text{----- (2)}$$

Where 'K' is constant, ' E_g ' is the energy gap and ' $h\nu$ ' is photon energy.

The plot of $(\alpha h\nu)^2$ with ' $h\nu$ ' for as deposited Lanthanum sulphide films are shown in fig (2a)& (3a). The linear nature of the plots suggests that the mode of optical transition in these films is of direct. Extrapolations of these plots on the energy axis at $\alpha=0$ give the band gap energies (E_g) as 2.1eV & 2.4eV for deposition films[17].

Fig (1) shows a typical XRD scan of deposited the golden-yellow LaS thin films. The observation of many Bragg reflection peaks suggest that the films are polycrystalline. Furthermore, the Bragg peaks are fairly broad suggesting the presence of polycrystalline grains of different sizes. Using Scherrer's equation[18,19], the size of the nano crystalline grains in the films can be estimated from the full width at half maximum of the Bragg peaks. The average size of the nano crystalline grains in the LaS films was found to be 14.37nm[20].

The Variation of the optical absorption coefficient (α) with wavelength (λ) is shown in fig(2b)& (3b). The absorption coefficient for LaS films are found to be of the order of 10^5 cm^{-1} supporting the presence of direct band gap [21,9].

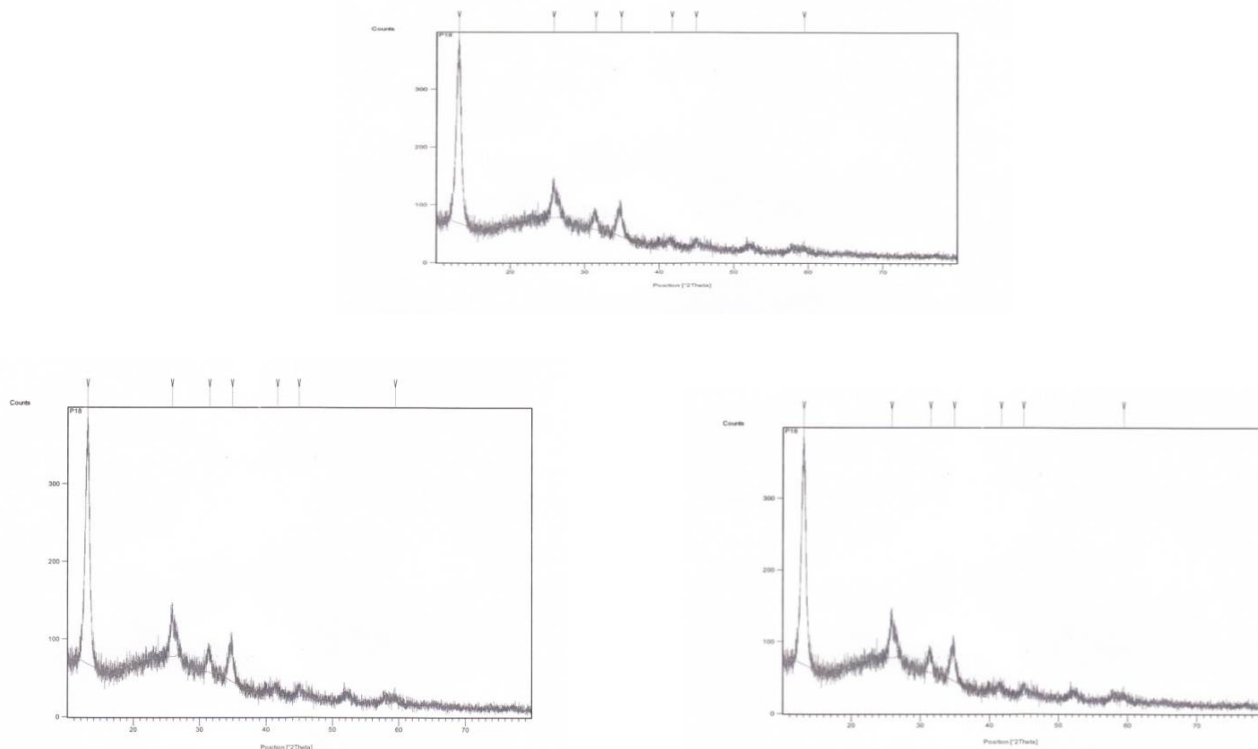


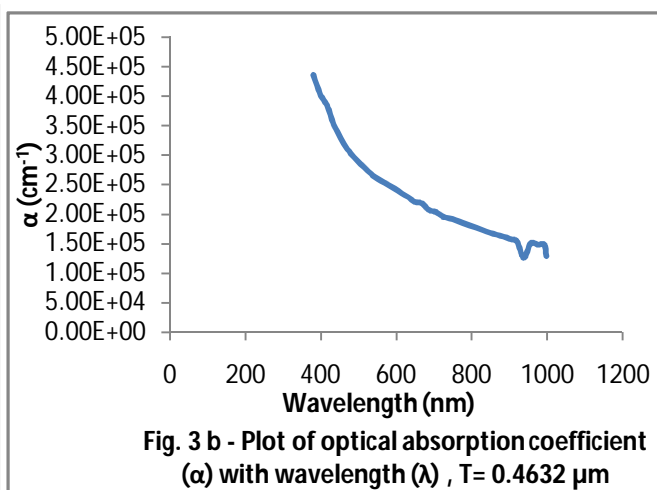
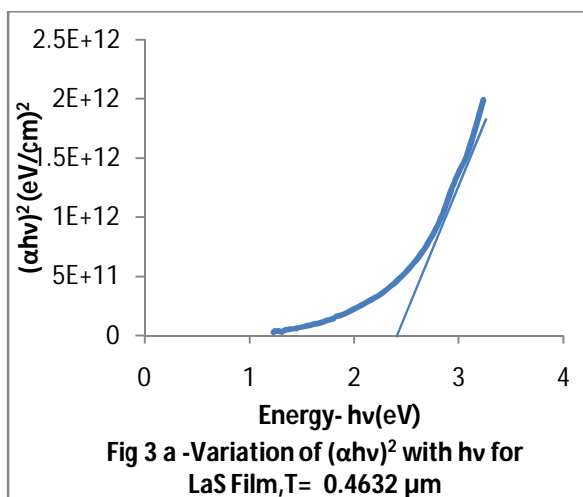
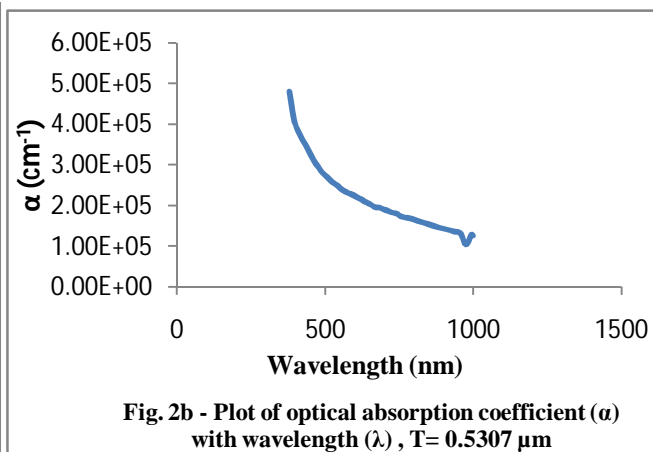
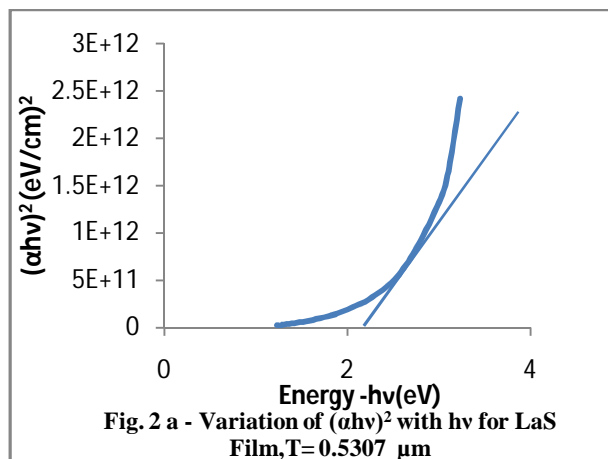
Fig. 1- X- Ray diffraction of LaS thin film of different thickness

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Optical absorption spectra of Lanthanum sulphide has been studied in the wavelength range 380-1000 nm. The variation of optical absorption coefficient (α) with wavelength (λ) is shown in fig.(2b) and (3b). The absorption coefficient for LaS thin films was found to be of the order of 10^5 cm^{-1} .

Fig. (2a) and (3a) shows the plot of $(\alpha h\nu)^2$ vs. $h\nu$ for LaS films. The plot of $(\alpha h\nu)^2$ vs. $h\nu$ has been found to be linear. One indicating that the transition is a direct and the energy band gap E_g was found to be 2.1 eV and 2.4 eV [10].

IV. CONCLUSION

It is concluded that the LaS films can be deposited on glass substrate at 300°C temperature by spray pyrolysis technique. The deposited films are polycrystalline, the optical energy band gap was found in the range of 2.1 eV to 2.4 eV with increase in concentration.

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