# Effect of Film Thickness on the Optical Properties of Las Thin Films Deposited by Spray Pyrolysis Technique

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**Abstract: Thin films of LaS were prepared by using spray pyrolysis technique at 270 0 C and thickness were varied by changing the concentration of reactant solution. The films were optically characterized and their variations with film thickness were studies. It was found that thickness can be tuned by varying concentration of reactant solution. The band gap was found to vary between 2.35eV to 2.50eV. The deposited films show improvement in optical properties with the increase in film thickness which is reflected in values of refractive index, extinction coefficient and average transmission of the films.**

**Keywords: LaS, spray pyrolysis, band gap, refractive index, extinction coefficient.**

## I. INTRODUCTION

Lanthanum sulphide belongs to III-VI compound semiconductor material. LaS are known to exist in different phases by creating lanthanum vacancy [1]. Preparation of Lanthanum sulphide thin films is important considering the point as lanthanum sulphide materials generally exhibits good optical transmission in the infrared region and are often studied as potential optical material. LaS is a semiconductor material having direct band gap energy of 2.5 eV and has many applications including superconductivity, magnetic cooling, photovoltaic devices, thermoelectric devices, for infrared transmitting window materials and magnetic thin films [2]. *g*-$La_2S_3$ films were used in infrared transmitting material for window applications [3]. Many researchers [1,2-4] have reported LaS with varied thickness by varying different deposition parameters for deposition of thin films and had carried out the optical studies of LaS thin films. However, very less attention is given for tuning of optical energy band gap by varying volume of solution.

## II. EXPERIMENTAL

Preparation LaS were carried out by using AR grade chemical on a pre heated glass substrate by using spray pyrolysis technique. The substrate temperature and solution concentration were optimized to get uniform, pinhole free and adherent LaS thin film. Solution of lanthanum chloride and thiourea both were prepared by varying the volumes of these 1M solutions to obtained La:S ratio of 5ml:5Ml and 7.5ml:7.5ml. The resultant solution was sprayed onto a preheated glass substrate. The spray rate was maintained at 1ml/min. The substrate temperature was kept at 270 ± $1^oC$ accuracy. These thin films formed were optically characterized by using Simadzu double beam spectrophotometer.

## III. CHARACTERIZATION

The thickness of the LaS thin film was determined by using the gravimetric method by using following relation:

$$t = \frac{\Delta m}{\rho_s A}$$

Where, A is the area of the thin film deposited on glass substrate, $\Delta m$ is the mass of the deposited tin film and $\rho_s$ is the bulk density of LaS. The weight difference method is being widely used and well accepted to determine the film thickness [4]. The thickness of thin films is found to vary from 391.8nm to 457nm with the increase of volume concentration of lanthanum chloride and thiourea from 5ml to 7.5 ml for 1 M solution.

## IV. RESULT AND DISCUSSION

The optical characterization of LaS thin film was carried out by using Shimadzu double beam UV-1700 UV-Visible spectrophotometer at normal incidence at room temperature. The extinction coefficient (k), refractive index (n) and energy band gap ($E_g$) were computed by using the transmission and reflection data. The band structures of deposited films were obtained by means of optical absorption. The thin films were scanned optically in UV and Visible region using double beam Shimadzu Pharmaspec UV-1700 UV-Visible spectrophotometer.

Figure 1 shows the variation of transmission with wavelength ($\lambda$). The transmission spectra shows that the average value of transmission decreases with increase in film thickness in the visible region of electromagnetic spectrum. The prominent peaks for film thickness 457 nm shows optical improvement in thin film which is due to increase in crystallinity as compare to thin films of thickness 391.8 nm. The low transmission for the film having thickness 475nm is the strong evidence that the LaS thin film can be used as a photosensitive material.

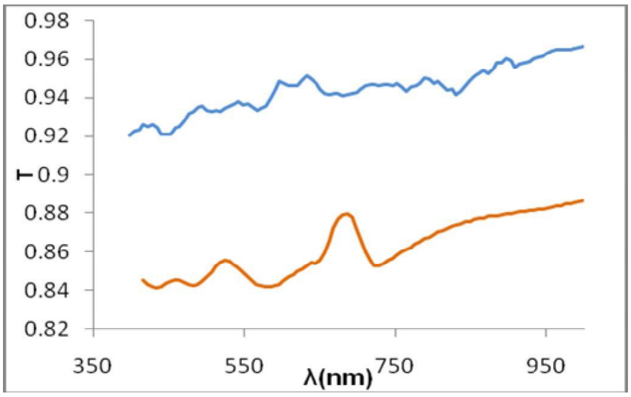


Figure1: Transmission spectra

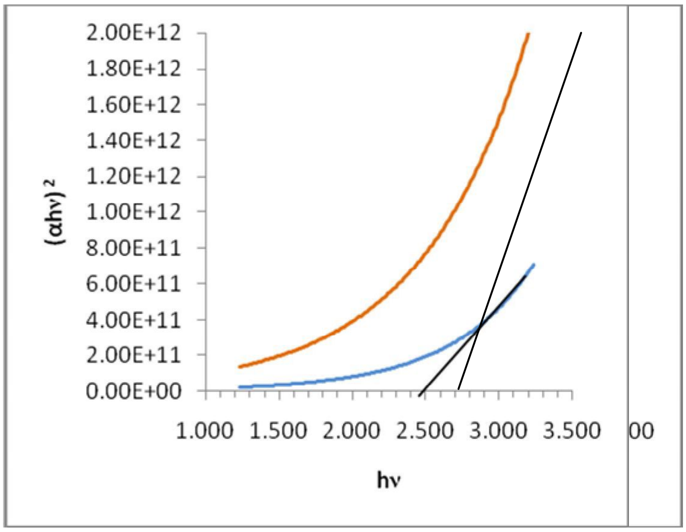


Fig 2: Variation of $(\alpha h\nu)^2$ Vs. photon energy ($h\nu$)

The nature of transition is determined by using the relation [6-10]:

$$\alpha h\nu = A(h\nu - E_g)^n$$

Where, A is a constant, $h\nu$ is the photon energy and $E_g$ is the optical band gap. The value of n depends on the type of transitions (direct: n = ½, direct forbidden: n = 3/2, indirect: n = 2, indirect forbidden: n = 3). Figure 2 shows the variation of $(\alpha h\nu)^2$ versus $h\nu$ indicating that direct transition is the dominant transition involved. The energy gap is obtained by extrapolating the linear portion of the $(\alpha h\nu)^2$ versus $h\nu$ plot to $\alpha h\nu = 0$. The energy band gap is found to be 2.35 eV and 2.5eV which are in agreement with the energy band gap obtained by previous workers [1,2-5].

The optical constants (n, k) are determined from the transmission and reflection data [11,12]. The extinction coefficient (k) of thin films has analytical importance in interaction of light with thin layer materials. The extinction coefficient (k) for a film thickness (t) has been calculated from the measured transmittance as a function of wavelength as;

$$k = \left[ \frac{2.303 * \log_{10} \left( 1/T \right) \lambda}{4 \Pi t} \right]$$

The refractive index (n) can be determined from reflection (R) and k using a relation;

$$R = \frac{(n-1)^2 + k^2}{(n+1)^2 + k^2}$$

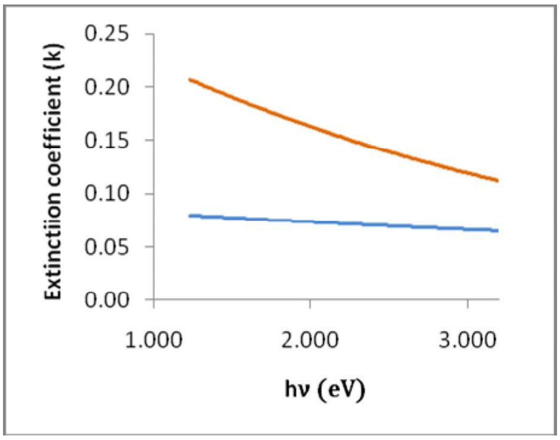


Figure 3: Extinction coefficient vs. photon energy (hν)

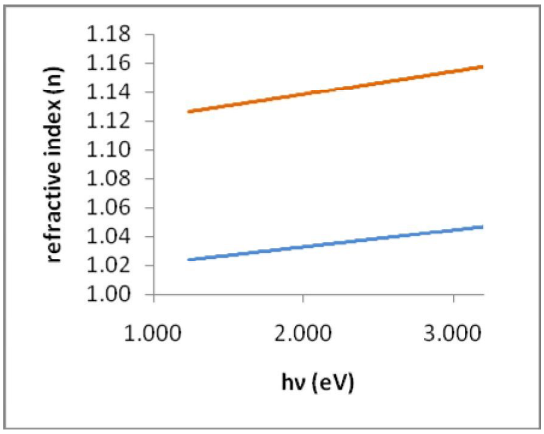


Figure 4: Refractive index vs. photon energy (h□)

Figure 3 shows the variation of extinction coefficient with photon energy (h□) is an important approach of optical interaction. The value of extinction coefficient (k) is almost found to increase in high visible region and near IR of electromagnetic spectra. It was also observed that extinction coefficient decreases with the film thickness as extinction coefficient gives the measure of how well material absorbs the electromagnetic radiation. Figure 4 show the plot of refractive index of thin films and photon energy (hν). The high value refractive index for film having thickness of 457nm as compare to 391.8nm thickness can be attributed to the incorporation of LaS with high concentration. Consequently the refractive index increases with LaS contents.

## V. CONCLUSION

Lanthanum sulphide thin films were successfully deposited using spray pyrolysis technique at substrate temperature of $270^0$C. The optical energy band gap was is found to be varying from 2.25eV to 2.5eV with increase concentration. The transmission spectra extinction coefficient and refractive index show shows optical improvement in thin films with increase in concentration.

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