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Effect of Annealing Temperature on Optical Parameters of LiF Films

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ABSTRACT

Elevated annealing temperatures affect on optical parameters of Lithium Fluoride (LiF) like transmittance, optical energy gap, and optical constants. Films of LiF were prepared under evaporation technique at 300 K at 400 nm thickness. Annealing temperature were made for films at (323, 423, and 473) K. The optical energy gap increases with the increase of annealing temperature between 3.7 eV at 300 K to 3.8 eV 473 K. The transmittance increases with the increase of annealing temperatures. Also Optical constants were varied with annealing temperatures.

INTRODUCTION

Lithium fluoride is an inorganic compound with the chemical formula LiF and it is a colorless solid. LiF has large band gap, so it is transparent to short wavelength Ultra Violet radiation. Also it is transparent to Visible Light as indicated in the present paper where optical parameters of LiF films were studied at room temperature like the transmittance, optical energy gap, and optical constants (refractive index and extinction coefficient). The studied was included effect of annealing temperature on optical parameters. Different researchers studied structure of Lithium compound and Fluoride compound (Ivanov, 2011) and (Zhengqiong, 2014). Also its properties like shifts of energy gap with pressure were studied by (SAJID, 2013).

Experimental details:

Thin films of LiF compound were prepared by high vacuum thermal evaporation in an Edward E306A coating unit using (LiF) powder of (99.999%) purity supplied by (Ferak company). The samples were deposited at 300 K onto glass substrates cleaned by distilled water, pure alcohol, and then by ultrasonic vessel .Tungsten boat was used as the source holder and the pressure inside the chamber was better than 10^{-6} mbar. The rate of deposition is 0.9 nm/s and 16 cm distance between the source and the substrate of 400 nm film thickness. Films were treated within various annealing temperature (Ta=323, 423, and 473) K under vacuum ($2*10^{-2}$torr) for one hour. In this research the optical transmission spectra of LiF films was measured by UV –Visible spectrophotometer (type CENTRA FIVE A102) over the wavelength range (300-850) nm. The transmission spectra were used to determine the optical energy gap, the absorption coefficient (α), and the optical constants (refractive index (n), extinction coefficient (k), the real(ε_r) and imaginary parts(ε_i) of dielectric constant).

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RESULTS AND DISCUSSIONS

3.1 Transmittance Spectra:

Figure 1 represents the transmittance spectra for LiF thin films at 300 K and different annealing temperature. From the figure the transmittance increases with the increase of annealing temperature. This may be attributed to improve the arrangement of atoms with elevated annealing temperature. There is no shift to lower or higher wavelengths with the variation annealing temperature as shown in the figure. This is confirmed to vary the energy gap of the films due to movement the atoms as the increase of annealing temperature (Zhengqiong, 2014).

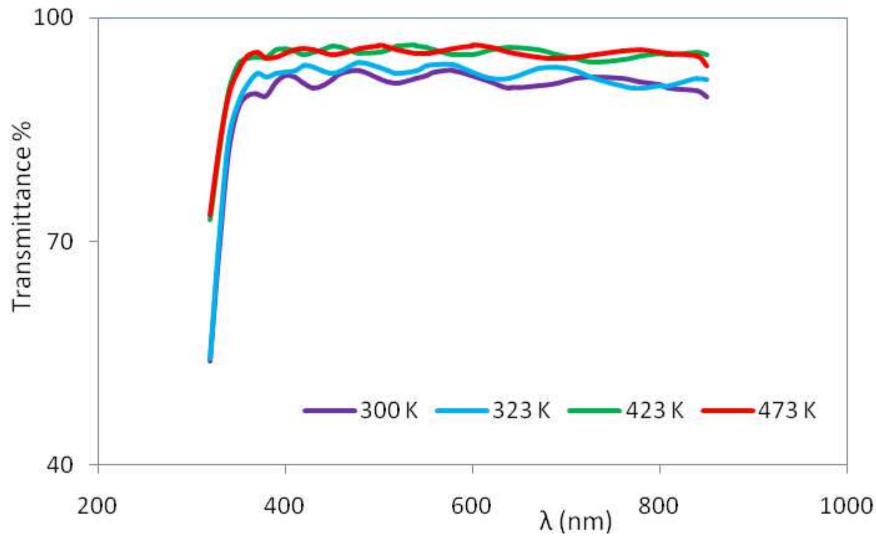

Fig. 1: the transmittance spectra for LiF films

3.2 Optical Energy Gap:

Optical energy gap can be calculated according to the relation (SAJID, 2013):

$$\alpha = 2.303 \left(\frac{1}{t}\right)\left(\log\frac{1}{T}\right) \qquad (1)$$

where $\alpha, t, and\ T$ are absorption coefficient, thickness, and transmittance.

Figure 2 represents the plot of optical energy gap for LiF films. The optical energy gap increases with annealing temperature due to increase the transmittance. Table 1 indicated values of energy gap with temperature.

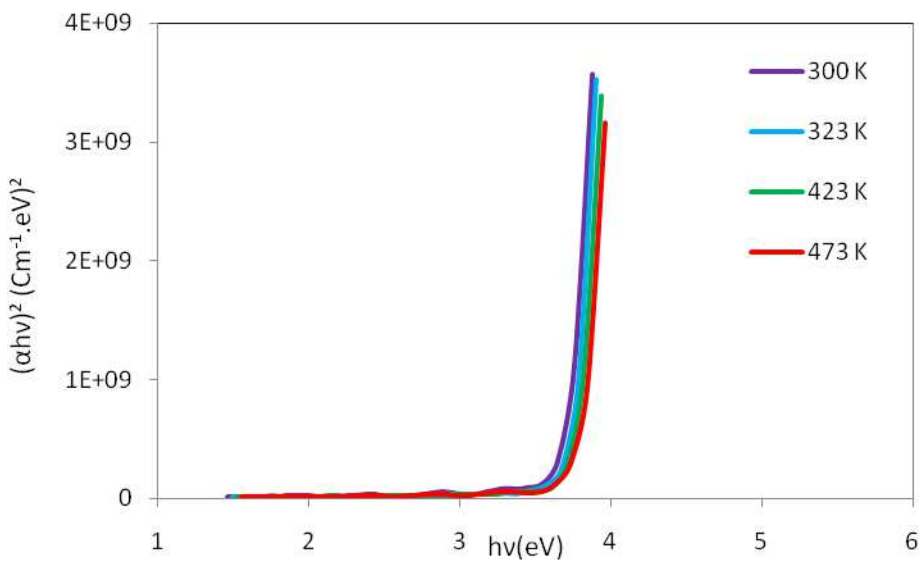

Fig. 2: the plot of optical energy gap for LiF films

Table 1: values of energy gap of LiF films

Annealing Temperature (K)	Energy Gap (eV)
300	3.7
323	3.73
423	3.77
473	3.8

3.3 Optical constants:

3.3.1Refractive Index:

From equation 2 can be obtained refractive index as (Stepanov and Raransky, 2011):

$$n = \left(\left(\frac{4R}{(R-1)^2}\right) - k^2\right)^{0.5} - \left(\frac{(R+1)}{(R-1)}\right) \qquad (2)$$

where $n, R, and\ k$are refractive index, reflectance, and extinction coefficient.

Figure 3 represents the plot of refractive index. The refractive index increases with increasing annealing temperature. This can be attributed to increase the optical energy gap with annealing temperatures (Haider, 2015).

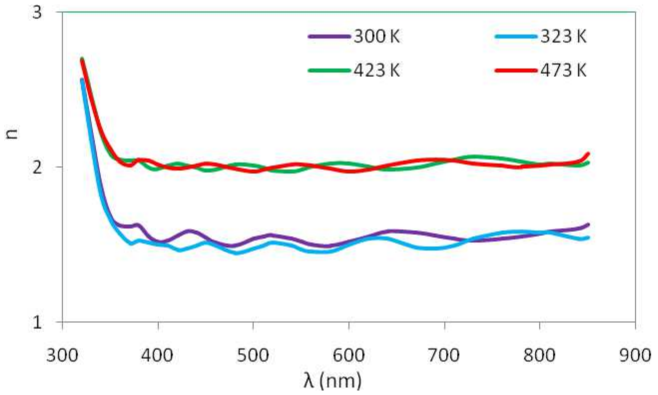

Fig. 3: the refractive index with wavelength

3.3.2 Extinction Coefficient:

According to equation 3 extinction coefficient cab be calculated as:

$$k = \frac{\alpha\lambda}{4\pi} \qquad (3)$$

where λ is the wavelength.

Figure 4 shows the plot of extinction coefficient with wavelength. The extinction coefficient represents the attenuation in a specific region of incident radiation. From the figure it increases with annealing temperature which is due to the movement atoms with elevated temperature and the attenuation increases in infrared region (Haider, 2015).

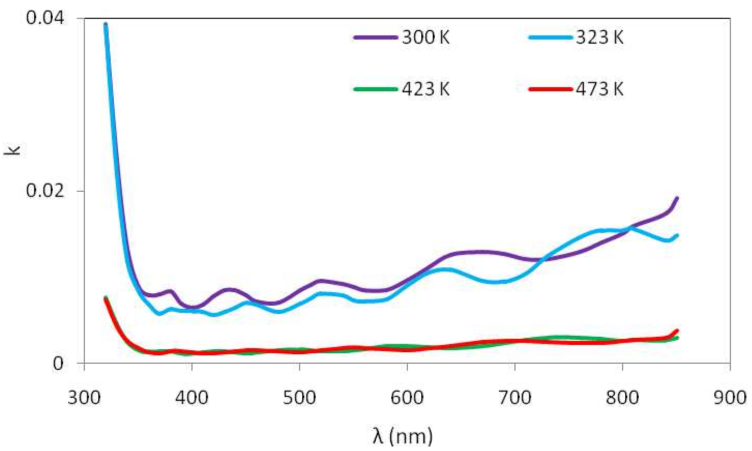

Fig. 4: the extinction coefficient with wavelength

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3.3.3 Real Part of Dielectric Constant:

The real part of dielectric constant can be calculated from the equation:

$$\varepsilon_1 = n^2 - k^2 \qquad (4)$$

where ε_1 is the real part of dielectric constant.

Figure 5 indicates the plot of real part of dielectric constant. It is observed that the real part increases with increasing annealing temperature and this may be explained to increase the polarized charges with the electric field of the electromagnetic radiation through the rearrangement of atoms with the elevated annealing temperature (Hesham, 2016 and Drabik, 2014).

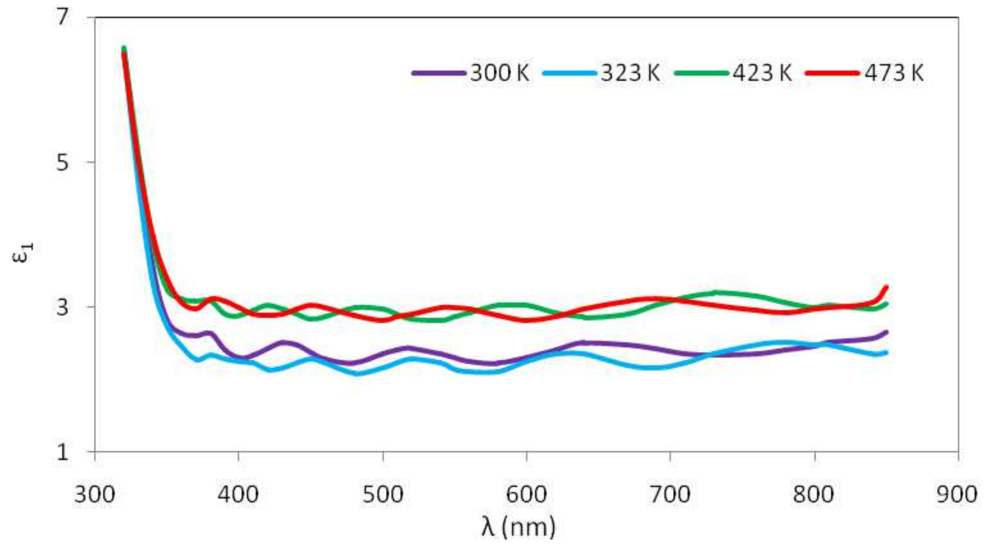

Fig. 5: the real part of dielectric constant with wavelength

3.3.4 Imaginary Part of Dielectric Constant:

The imaginary part relates with the extinction coefficient according to the relation:

$$\varepsilon_2 = 2nk \qquad (5)$$

where ε_2 is the real part of dielectric constant.

Figure 6 shows the relation between the imaginary part of dielectric constant with wavelength. The imaginary part represents the lost energy due to the response or not of atoms under the effect of electric field of magnetic radiation. From the figure it increases with the increase of annealing temperature.

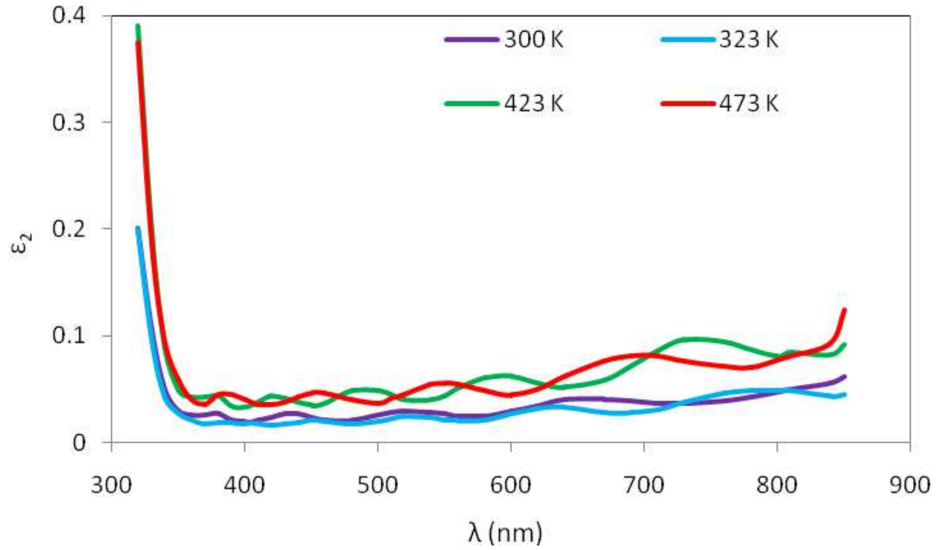

Fig. 6: the real part of dielectric constant with wavelength

Conclusion:

Films were prepared from LiF powder by thermal evaporation method onto cleaned glass substrate at 300 K at 400 nm thickness. Optical parameters of LiF films like transmittance, optical energy gap, and optical constants were affected after heat treatment of films at annealing temperatures (T_a = 323, 423, and 473) K. The refractive index increases due to increase the transmittance. The optical energy gap increases from 3.7 eV at 300 K to 3.8 eV at 473 K.

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