Effect of annealing temsperature on some optical properties of LiF thin films

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Abstract

LiF Polycrystalline thin films have been prepared by using thermal evaporation technique on substrates of glass heated at room temperature under vacuum of (10^{-6}mb) and the thickness of films was (400 nm). After that the films were treated thermally at pressure (10^{-3} mb) and a temperature of (323 K) ,(423 K) and (473 K) for one hour.The optical measurements which is included the absorbance spectra using UV-VIS spectroscopy in the spectrum range (250-850)nm demonstrated that the values of the absorption coefficient (α) was greater than (10^4cm^{-1}) and then (α) decreases with increasing of annealing temperature (Ta).

Moreover, the absorbance spectra were used to find some optical constants such as refractive index (n), extinction coefficient (k) and dielectric constant (ε), and it was found that the optical constants were affected after treating the films thermally.

Introduction

In the last few years, there has been considerable interest in growing crystalline fluoride films[1] . Among all the fluoride materials, is lithium fluoride (LiF) . Lithium fluoride is a chemical compound of lithium and fluorine . It is a white , inorganic , crystalline , ionic , solid salt under standard conditions [2] . The important properties of this material are : wide band gap (~ 13.6 eV) ,very low refractive index (n= 1.39) , Face-Centered Cubic structure and a lattice constant of (~ 4.03Ǻ) [3,4] .These properties are desirable for windows , prisms and lenses in the vacuum ,UV, Visible and infrared where desire transmission is in the o.104 µm [3,4]. LiF thin films have been prepared with different process , such as 1- Plasma-enhanced chemical vapour deposition 2- Ion-assisted thermal deposition in presence of Xe low-energy ions (< 200 eV) on transparent amorphous substrates [5,6] .

In present study , the first time ,(LiF) thin films have been prepared by thermal evaporation technique , and the effect of annealing temperature on some optical properties have been investigated .

Experimental details

LiF Thin films have been prepared by thermal evaporation technique on to glass substrates under vacuum at pressure near (10^{-6}mb) . The glass substrate was cleaned in methanol for 15 min using an ultrasonic cleaner and then rinsed with deionized water and dried . The substrate temperature (Ts) was used in room temperature R.T (303K) . The thickness of films was determined by optical interference fringes method and found to be(400 nm) . The films were clear , transparent , having very good adhesive properties and smooth surface free from pinholes . On the other hand, These films have been annealed at different annealing temperatures Ta (323K) , (423K) , and (473K) .Optical Absorbance was recorded with double beam (UV / VIS) (Shimadzu Corporation Japan) in the wavelength range (300 – 900) nm . The effect of annealing temperatures on some optical properties of (LiF) thin film have been determined .

Results and discussions

The optical properties of LiF thin films deposit on glass substrate at room temperature and annealed at different annealing temperatures (303,423 and 473) K have been determined using UV-visible near infrared transmittance spectrum in the region of (250-850) nm.

1. Absorpance Spectrum

The absorbance spectrum(A) for LiF thin films with different annealing temperatures (Ta) is shown in Fig. (1). This spectrum reveals that films grown under the same parametric conditions, have low absorpance in visible /near infrared region from 350nm to 850nm. However, absorbance is high in the ultraviolet region. It is obvious from this figure that the absorbance decreases and shifts to shorter wavelengths with increasing of annealing temperature(Ta) and this may be due to improving the crystallite size and increasing the transmittance.

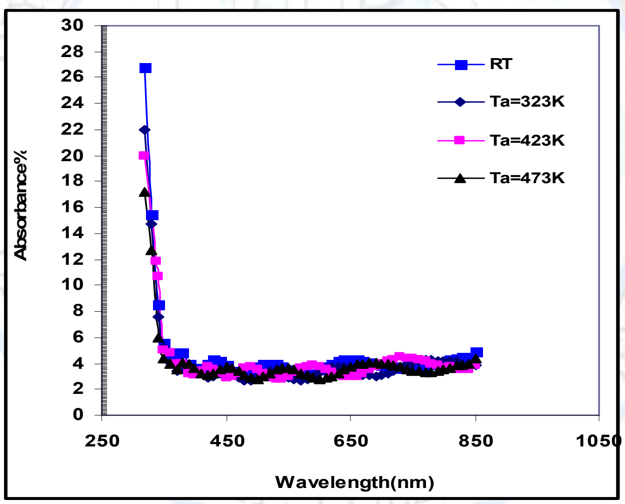

Fig.(1) Absorbance spectrum as a function of wavelength for LiF films at different annealing temperatures.

2. The Absorption Coefficient

The dependence of the absorption coefficient (α) on the annealing temperature (T_a) of LiF thin films as a function of wavelength is shown in Fig.(2). One can see from this figure that the absorption coefficient of the LiF films is characterized by strong absorption at the shorter wavelength region between (250-350) nm .

In the shorter wavelength the absorption coefficient exhibits high values of α ($\alpha > 10^4$ cm^{-1}) which means that there is a large probability of the allowed direct transition and then α decreases with increasing of wavelength. Also we can notice from these figures that α decrease with increasing of (T_a) for all annealed films as given in Table 1 and this is due to the increasing of energy gap with T_a.

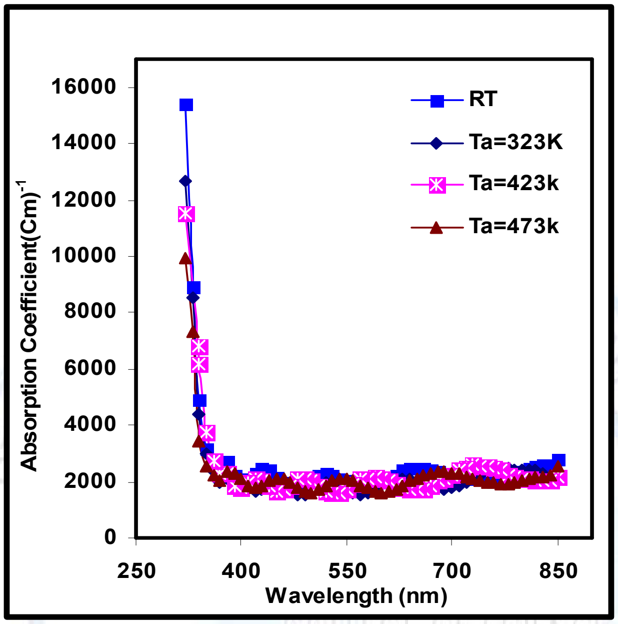

Fig.(2) Absorption coefficient ion of wavelength for LiF thin films at different annealing temperatures .

3.Refractive index

The refractive index(n) is a significant factor in optical communication and in designing devices for spectral dispersion. The refractive index of the LiF thin films were calculated by the following relation [7]:

$$\left(\frac{1+R}{1-R}\right)^2 - \left(K^2+1\right)^{1/2} + \left(\frac{1+R}{1-R}\right) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where n is the refractive index and k (=αλ/4π)[8] is extinction coefficient. When the thickness of film is known, then the computation can be carried out and the optical constants can be calculated.

The variation of the refractive index versus wavelength in the rang(250-850) nm, at different annealing temperatures(Ta) is shown in Fig.(3).

We can notice from this figure and Table (1) that the refractive index increases slightly with increasing of T_a. This behavior is due to the increment in energy gap which causes expansion of the lattice and growth of the grain size and decreases the defect which means increasing of the reflection where the refractive index depends on it.

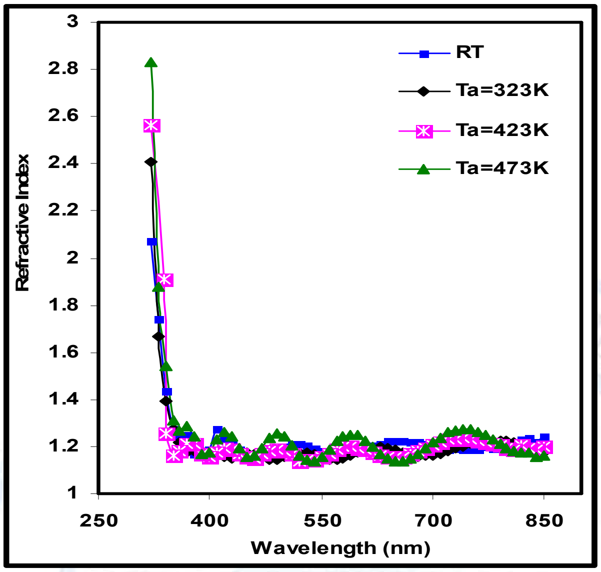

Fig.(3) The refractive index as a function of wavelength for LiF films at different annealing temperatures. annealing temperatures.

4.Extinction Coefficient

Fig.(4) shows the extinction coefficient (k) as a function of wavelength for LiF thin films at different annealing temperatures(Ta). One can be observed from this figure that the behavior of extinction coefficient (k) is nearly similar to the corresponding absorption coefficient(α). The extinction coefficient decreases with increasing of annealing temperature.This is attributed to the same reason mentioned previously in absorption coefficient(α) .

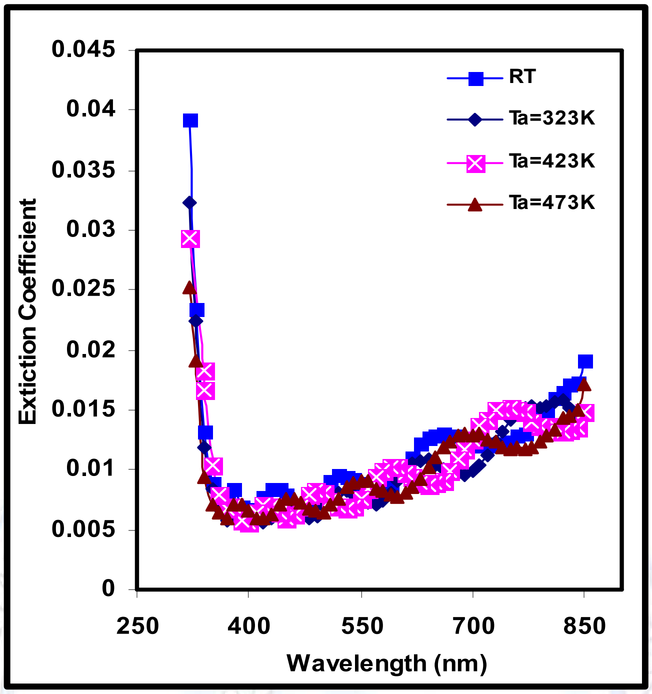

Fig.(4) The extinction coefficient as a function of wavelength for LiF films at different annealing temperatures.

5.The dielectric constant

The dielectric constant ε(ω) is defined as, $\varepsilon(\omega)= \varepsilon_1(\omega)+i\, \varepsilon_2(\omega)$ where the real ε_1 and imaginary ε_2 parts of the dielectric constant are related to the n and k values respectively . The $\varepsilon_1$and $\varepsilon_2$values were calculated using the formulas [9] ,

$$\varepsilon_1(\omega) = n^2(\omega) - k^2(\omega) \text{--}(2)$$

$$\varepsilon_2(\omega) = 2n(\omega)k(\omega) \text{---}(3)$$

Both ε_1 and ε_2 values decrease with increasing wavelength. These values were calculated at λ=350 nm.

The variation of the real (ε_1) and imaginary (ε_2) parts of the dielectric constant values versus wavelength in the range (250 – 850) nm at different annealing temperatures(Ta) are shown in Figs.(5 and 6). The behavior of ε_1 is similar to that of refractive index because the smaller value of k^2 compared with n^2, while ε_2 is mainly depends on the k values, which are elated to the variation of absorption coefficient. It is found that ε_1 increases while ε_2 decrease with increasing of annealing temperatures(Ta). The values of ε_1 and ε_2 is tabulate in table 1.

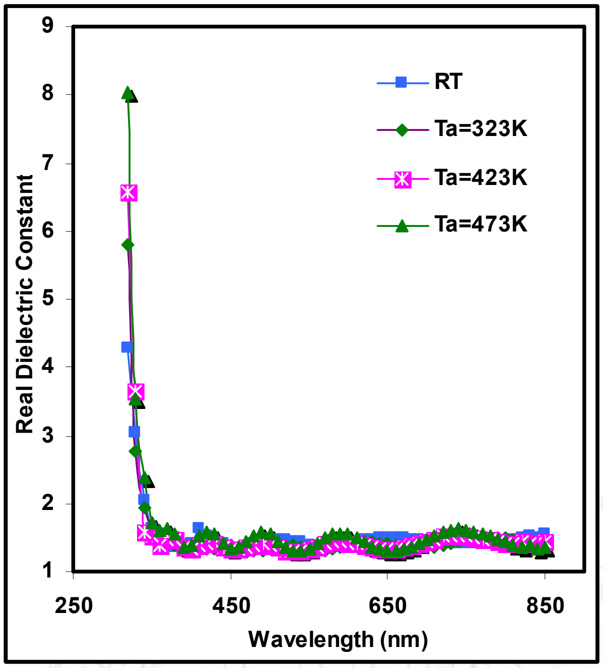

Fig.(5) The real part of dielectric constant as a function of wavelength for LiF films at different annealing temperatures.

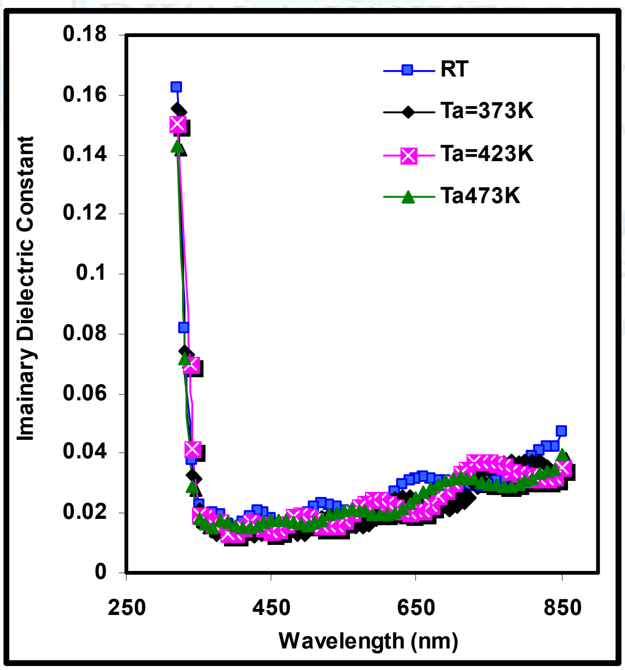

Fig.(6) The imaginary part of dielectric constant as a function of wavelength for LiF films at different annealing temperatures.

Table 1 represents the optical parameters of LiF thin films at λ =350 nm

Ta(K)	α*$10^4 cm^{-1}$	n	k	ε_1	ε_2
RT	3.17	1.28	0.088	1.63	0.022
303	2.99	1.29	0.0083	1.62	0.021
423	2.874	1.30	0.008	1.522	0.019
473	2.53	1.31	0.007	1.31	0.018

Conclusions

Lithium fluoride (LiF) thin films have been successfully prepared by thermal evaporation are polycrystalline in nature . From the obtained results of these films, we conclude the following:

1- The absorbance is high in the ultraviolet region and decreases with increasing of annealing temperature.

2- The absorption coefficient decreases with increasing of annealing temperature.

3- The refractive index increases slightly and the extinction coefficient decreases with increasing of annealing temperature.

4- The variation of the real and imaginary parts of the dielectric constant have similar trend as for refractive index and extinction coefficient respectively.

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