World Applied Sciences Journal 22 (6): 817-818, 2013
ISSN 1818-4952

DOI: 10.5829/idosi.wasj.2013.22.06.370

Temperature Variation of BK7 Substrate and this Effects on Structure and Optical Propertis of *MGF_2* Thin Films

Tabatabaei Abdolrahman, Shahriari Majid and Jamei Maryam

Islamic Azad University, Ahwaz branch, Ahwaz, Iran

Abstract: The MgF_2 thin films are coated on BK7 substrate in different temperature with thermal evaporation method. Behavior of reflection power and refractive index are studied in different temperature of substrate. The MgF_2 thin films on cold substrate are porous and absorb remanent humidity in vacuum chamber. Variation of optical properties such as reflection power, refractive index and packing density in different times are studied. The results show a nearly linear increase of index with temperature of substrate and packing density reaches a value near unity.

Key words: MgF_2 thin films · Reflection power · Refractive index · Packing density

INTRODUCTION

The coated MgF_2 thin films, with thermal evaporation, have porous structure. The diameter of this narrow holes are 13-20 nm in order [1]. This holes absorb remanent humidity in vacuum chamber when thin films are being made or ejected from chamber. The hygroscopic of thin films show different optical behavior in different conditions and there by their packing density is changed. The investigation have been show that increase in temperature of substrate, before coating, would break holes in thin films and improve refractive index moreover packing density would tend to 1. The relation between refractive index and reflection power is given in (1), (2) n_f ., R are refractive index reflection power of thin film in vacuum condition, respectively. n_f are refractive index and reflection power in air adjacent. n_g is refractive index of substrate [2].

$$n_f = \left[n_g \left(\frac{\left(1+\sqrt{R}\right)}{\left(1-\sqrt{R}\right)} \right) \right]^{1/2} \tag{1}$$

$$n_f^* = \left[n_g \left(\frac{1+\sqrt{R^*}}{1-\sqrt{R}} \right) \right]^{1/2} \tag{2}$$

The packing density in different condition is given with [3].

$$p = \frac{0.33 + n_f - n_f^*}{0.33} \tag{3}$$

Experimental Results: The MgF2 thin films are made by coating tantalum bulk on BK7 substrate (n_g ˜ 1.52) with evaporation method. The pressure of vacuum chamber is $2\text{-}4 \times 10^{-5}$ milibar and evaporation rate is $1\frac{nm}{s}$.

The thickness of thin films is measured by mass methods and optical thickness monitoring GSM420. With this system we can measure reflection power of thin films with different wavelengths, moreover we can finish coating in optimum reflection.

The reflection and transmission spectrum of thin films can be measured in different temperature and pressure of vacuum chamber , before and after coating. Therefore it is important to consider the effective parameters such as temperature , initial pressure , coating rate and effective conditions such as air adjacent and it is effects on optical properties of thin films.

In this paper light source is Halogen lamp that is modulated with 130HZ frequency. The detection range in 500-800 nm is made by monochromators such as diffraction grating with 600 line per millimeters and ad hoc

Corresponding Author: Shahriari Majid Islamic Azad University, Ahwaz branch, Ahwaz, Iran.
Tel: +989167577987.

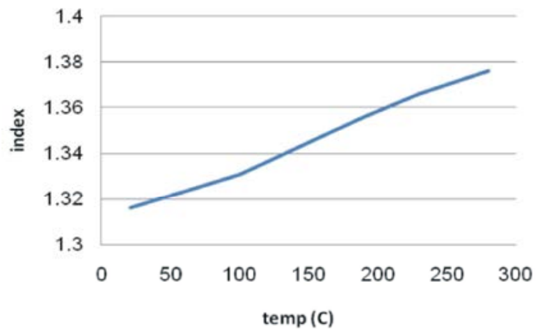

Fig. 1: Plot of refractive index of thin film versus temperature

Table 1: Variations of R and n_f in different temperature of substrate

Temperature of substrate °C	21	100	190	230	280
R	0.43	0.58	0.9	1.05	1.2
n_f	1.316	1.331	1.356	1.366	1.376
n_f d(nm)	320	133	135	136	377

Table 2: Variations of optical properties of films on cold substrate in different times.

Time	n_f	$R_{\lambda=550}$ (%)	R_{min} (%)	λ_{min} (%)
After coating	1.316	0.43	0.43	550
Several minute after coating	1.322	0.49	0.46	560
After air adjacent in vacuum chamber	1.356	0.9	0.7	585
20 minute adjacent in vacuum chamber	1.376	0.97	0.76	590

filters. The silicon diode is used as light detector. R and n_f are measured in different temperature of substrate and recorded in Table (1).

The coating of substrate is made with optical thickness monitoring. The optical thickness of thin films is and the temperature range is from room temperature until n_f d=3λ/4. The behavior of refractive index of thin films , after coating , is plot versus different temperature of substrate (Figure 1).

The absorption of air humidity by porous structure of MgF2 with cold substrate is studied by measurement of reflection curve of thin films in different times. The displacement of minimum reflection in cold film and different between refractive index of thin films before air adjacent and after it (Table 2), all are because the existence of porous holes in cold thin films and their low packing density and the saturation of holes by air humidity.

The packing density of thin films with cold substrate is 0.86 by EQ 3.($n_f = 1.316, n_f^* = 1.376$). for hot substrate (there is not fluctuation in optical behavior) packing density is closed to 1. By heating thin films ,until 300oC, the humidity in holes of films is evaporated and packing density is decrease from 0.86 to 0.78.

CONCLUSIONS

- The MgF_2 thin films coating on cold substrate BK7 are porous and absorbing humidity even in vacuum condition. when film and substrate are heated with optimum temperature, humidity in holes are evaporated but in air adjacent this holes absorb humidity again. Therefor increasing in temperature of films, after coating, could not breaking porous holes in thin films.
- The thin films penetration by humidity would be changing their optical properties, such as reflection power, packing density.
- Before coating, the heating of substrate would be improving conditions. The porous structure of thin films are removed by increasing temperature until 300°C. therefore diffraction index is closed to 1.38 and packing density is closed to 1.
- When temperature of substrate is increased to optimum temperature, the probability of absorbing humidity would be zero and optical behavior is improved in different condition of thin films even in air adjacent.

REFERENCES

1. Macleod, H.A., 2002. "thin film optical filters" 3th Ed., (Adam Hilger, London,).
2. Baldwin and… at 40 th annual technical conference proceeding, 1997.
3. Martin and …Appl. Opt., 2006. 26: 7.
4. Perales, F., J.M. Herrero, D. Jaque and C. De las Heras, 2007. "Improvement of MgF2 thin coating films for laser applications", Original Research Article. Opt., 29(7): 783-787.
5. Hoon, S. Woo and C.H. Kwon Hwangbo, 2007. "Surface and Coatings Technology", Vol 201, Issues 19–20, 5 August, Pages, pp: 8250-8257.