



ELECTRICAL AND OPTICAL PROPERTIES OF THIN FILM OF MAGNESIUM FLUORIDE WITH OTHER LAYERS

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Abstract: Dielectric, anti-reflective, or high reflective multilayer system consists of alternating dielectric layers of low and high refractive index. In the present work, a detailed study of various techniques for the preparation of thin films has been presented along with the various methods for characterizing these thin films [1,2]. The various modes of growth of thin films and a number of factors affecting the growth structure and film properties have been studied. A theoretical study of the electrical properties like relative dielectric constant and some optical properties like reflectance and transmittance of thin films of MgF_2 and other mixture of layers, using some mathematical tools has been investigated theoretically which may be experimentally verified.

Key words: Antireflective, Reflectance and Transmittance

I. Introduction

A thin film is a layer of material ranging from fractions of nanometre (monolayer) to several micrometre thicknesses. The controlled synthesis of materials as thin films (a process referred to as deposition) is a fundamental step in many applications. A familiar example is the household mirror, which typically has a thin film coating on the back of a sheet glass to form a reflective interface. Advances in thin film deposition techniques during the 20th century have enabled a wide range of technological breakthrough in areas such as magnetic recording media, electronic semiconductor devices, LEDs, optical coating (such as antireflective coatings) hard coating on cutting tools and for both energy generation (e.g. thin film solar cell) and storage (thin film batteries) It is also being applied to pharmaceuticals, via thin-film drug delivery. The range of materials deposited vary from semiconductor metals or alloys for contacts and insulator for passivation and interlayer separation. Recently the growing interest in nano-particles and Nano-crystalline films with various techniques has been adapted for preparation or deposition of nano-particles. In addition to their applied interest thin films play an important role in the development and study of materials with new and unique properties example multi-ferroic materials and super lattices that allow the study of quantum confinement by creating two dimensional electron states. There are several techniques available for thin films deposition on a single crystal substrate like thermal evaporation, chemical decomposition, and the evaporation of source materials by the irradiation of energetic species or photons [3,4]. In general the growth process of thin films exhibits the following features

- 1) Thin films of all materials created by any deposition technique starts with a random nucleation process followed by nucleation and growth stages
- 2) Nucleation and growth stages are dependent upon various deposition conditions, such as growth temperature, growth rate, the chemistry of the material and the substrate and their structure.
- 3) The nucleation stage can be modified significantly by external agencies, such as electron or ion bombardment
- 4) Film microstructure, associated defect structure, and film stress depend on the deposition conditions at the nucleation stage
- 5) The crystal phase and the orientation of the films are governed by the deposition conditions as well as by the structure of the substrate

II. Theory

The data for the refractive index for various layers of thin films of magnesium fluoride (MgF_2) along with the mixture of other layers like the mixture of zirconium oxide (ZrO_2) and titanium oxide (TiO_2), a magnesium oxide layer (MgO) are obtained by Radhika V et al.[5], which is used to find the various other electrical and optical properties using different physical relations, which are tabulated below

LAYER	MATERIAL	REFRACTIVE INDEX(n)
Substrate	Glass	1.62
I Layer	MgF ₂	1.385
II Layer	Mixture of ZrO ₂ and TiO ₂	2.05
III Layer	MgO	2.05

A relation between the electrical property i.e. relative dielectric constant (ϵ_r) and refractive index (n) is as follows [6,] -

$$n = \sqrt{\epsilon_r} \quad (i)$$

Also the optical properties like Reflectance (R) and Transmittance (T) is related to the refractive index (n) as [7]-

$$R = \frac{|1-n|^2}{|1+n|^2} \quad (ii)$$

$$T = \frac{4n}{|1+n|^2} \quad (iii)$$

The Transmittance can also be calculated from the law of conservation of energy as-

$$R+T=1 \quad (iv)$$

III. Calculation

The electrical properties i.e. relative dielectric constant (ϵ_r) and optical properties i.e Reflectance (R), Transmittance (T) percentage of reflectance (R') and percentage of Transmittance (T') for various layers of thin films is calculated theoretically and tabulated as follows-

Layer	Material	n	ϵ_r	R	T	(R')	(T')
substrate	Glass	1.62	2.624	0.059	0.944	5.9	94.4
I layer	MgF ₂	1.385	1.918	0.026	0.973	2.6	97.3
II layer	ZrO ₂ & TiO ₂	2.05	4.202	0.118	0.881	11.8	88.1
III layer	MgO	1.70	2.89	0.067	0.932	6.7	93.2

IV. Result and Conclusion

From the above results we have found that the optical properties like reflectance and transmittance of the various layers of thin films of MgF₂ and other layers of mixture of materials are dependent upon the refractive index of the materials of the films. The reflectance is low and the transmittance is high for the films having low refractive index as in the case of MgF₂ layers. The reflectance increases and the transmittance decreases as the refractive index of the films increases, as in the case of layer containing ZrO₂ & TiO₂ and MgO. Thus the lower refractive index of the thin film i.e., for MgF₂ layer is very suitable for antireflective coating. This is very useful for application in lenses, for use in telescope where high transmittance and low reflectance is required for better imaging purposes. Also it can be used in solar cells where most of the light can be used for the conduction of current.

Also the electrical properties like the relative dielectric constant (ϵ_r) of the film is directly dependent upon the refractive index of the film. Materials having high dielectric constant have higher electric flux density. This enables the thin films to hold their electric charge for a long period of time, or to hold large quantities of charge. This fact is very useful in the manufacture of high value capacitor.

REFERENCES

- [1] Larroquet, Juan I., and Ritva AM Keski-Kuha. "Far ultraviolet optical properties of MgF₂ films deposited by ion-beam sputtering and their application as protective coatings for Al." *Optics communications* 215, no. 1 (2003): 93-99.
- [2] Yang, Hyeon-Hun, and Gye-Choon Park. "A Study on the properties of MgF₂ Antireflection film for Solar Cells." *Transactions on electrical and electronic materials* 11, no. 1 (2010): 33-36.
- [3] Williams, M. W., R. A. MacRae, and E. T. Arakawa. "Optical properties of magnesium fluoride in the vacuum ultraviolet." *Journal of Applied Physics* 38, no. 4 (1967): 1701-1705.
- [4] Chopra, Kasturi. *Thin film device applications*. Springer Science & Business Media, 2012.
- [5] Radhika, V., and V. Annamalai. "Methods of Preparation of Anti-reflective MgF₂ Nano coating on glass substrate-A comparative survey." *Journal of NanoScience and NanoTechnology* 1, no. 1 (2013): P-45.
- [6] Edited by Maissel and Reinherd Geang, *Handbook of thin film technology*, international business machines corporation hopewell junction, N.Y, Mcgrow hill book company
- [7] Goswami, A. *Thin film fundamentals*. New Age International, 1996.