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Research Article

Optical Model of Sol-Gel Derived Al: Zno Thin Film

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Abstract

Optical model in Al:ZnO thin film was determined after the film was fabricated by sol–gel dip coating method. The vartiations in refractive index and extinction coefficient were commanded with the increase of the annealing temperature. The optical model indicated that refractive index and extinction coefficient tent to improve as the result of the rise in temperature by the application of heat treatment in argon.

Keywords: Optical Model; Sol–Gel Technique; Zinc Oxide

Introduction

ZnO doped with Al (ZnO: Al) film presents considerable concern as the optical transparent and electrical conducting electrodes. Al: ZnO thin film is electrically conductive when doped with aluminium. Aluminium is the suitable doping element to improve optoelectronic properties at Al:ZnO thin films at human body [1]. The refractive index is an important parameter for optical materials and applications [2-5]. The effect of annealing at refractive index and extinction coefficient for Al:ZnO thin films was examined with the rise of annealing temperature. ZnO with antibacterial properties has been an emerging trend for the augmentation and replacement of diseased ocular tissues and biomimetic materials recently. Besides, ZnO is one of eco-friendly semiconductor for the environment as it is non-toxic [6]. Hence ZnO nanostructures had not presented the considerable attention for the human body concerning among other harmful semiconductors. For the use of n- type semiconductor, toxic properties of indium and instability of ITO are the main impediment in biomedical applications. The low cost, less toxic and biocompatible zinc oxide (ZnO) takes the attention depending on one of the most popular metal oxide nanoparticles in biological applications as harmful semiconductors cause many health-related harmful effects such as irritation to the skin, eyes and respiratory tract. Al:ZnO has high chemical and thermal stability which makes it considerably attractive material for various applications areas [7-8].

In this study Al:ZnO as biomimetic anti-reflective coatings was derived by using an eco-friendly semiconductor production technique among other complex and expensive coating techniques such as electron beam evaporation etc. The determination of refractive index and extinction coefficient has provided to make an assessment in its optical model considering the cost effective production parameters for the ophthalmic biomaterials applications related with ophthalmology and optometry services. The changes in refractive index and extinction coefficient were evaluated to make an assessment at the practical and economic production parameter after Al:ZnO thin film was produced by sol–gel method.

Experiments

The plastic substrate coated with a thick protective coating (such as CR- 39) is generally dip-coated to produce a hard coat in order to increase the scratch resistance of ophthalmic lenses. Besides, the coating with a few microns thick displays optical properties close to those of the substrate while being mechanically harder [9]. Hence, the production method of Al:ZnO thin film was preferred as sol–gel dip coating method in this study. The details of the production process are available in the previous studies [6-8,10]. The diethanolamin DEA(CH_2CH_2OH)$_2$ was used as the stabiliser, and Al (NO_3)$_3$.9H_2O was utilized as Al doping source for synthesis zinc oxide by using biomimetic approach. The Al:ZnO thin film layers were produced with 1.0 and 1.2 (at.%) Al amount. The produced layers were dried at 200°C for 10 min.

The layers on soda-lime silicate substrates were annealed at 400, 450 and 500°C in argon for 1 hour to compare the annealing ambient effect on ZnO:Al thin film.

Results

An optical spectrophotometer was utilized to make an assessment for the optical properties. The transmittance properties were measured and their results presented in (Figure 1) to make an assessment at the optical model due to changes in optical transmittance and reflectance after annealing process [4]. The transmittance spectrum can be utilized to make an estimation for the thickness of the film following the Swanepoel's envelope method. The details about the calculations of the thickness, t_{hs} of the film, the determination of refractive index of the film, the extinction coefficient, κ and absorption coefficient, α, are given in the previous studies [5,10].

The visual reflectivity is ~45% in the general trend since the maximum human visual sensitivity is ~550 nm in the spectral reflection. Al:ZnO thin film samples at two different Al concentration values such as 1.0 and 1.2 (at.%) presented the considerable transmittance. Hence, refractive index and extinction coefficient were examined to compare each other at two different Al concentration by using results of transmittance and reflectance measurements considering the visible range. The rise of the annealing temperature caused to increase of refractive index of Al:ZnO thin film in (Figure 2). The alteration in extinction coefficient were presented due to the rise of the annealing temperature in (Figure 3) and the extinction coefficient of ZnO films changed when the annealing temperature of the thin film increased from 450 to 550 C. (Figure 4) presented the XRD patterns of the Al:ZnO thin film samples with 1.2 at.% Al and annealed at 450, 500, 550 and 600 C.

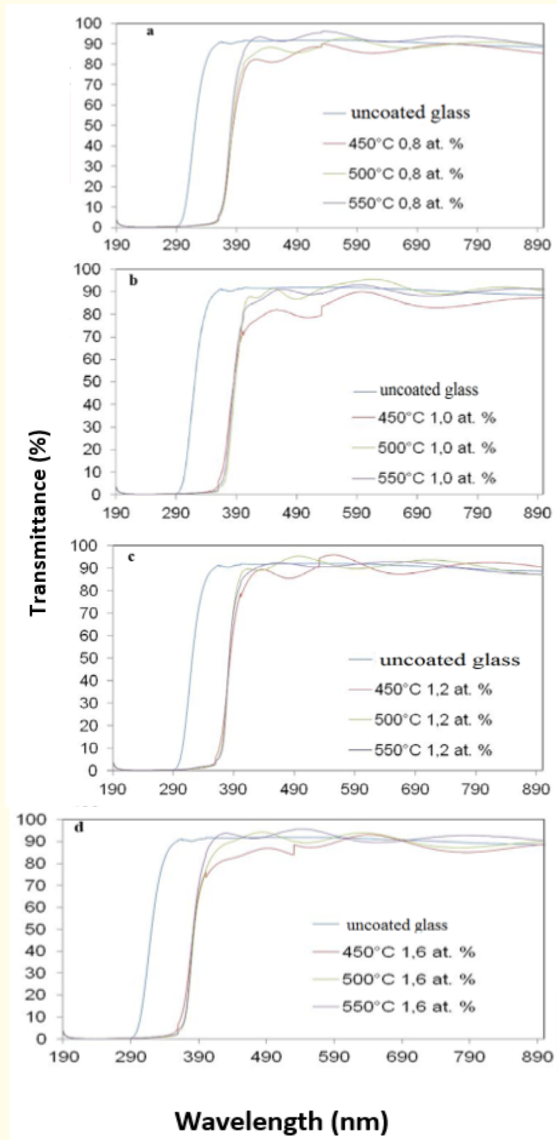

Figure 1: Optical transmission of Al:ZnO thin films at different annealing temperatures.

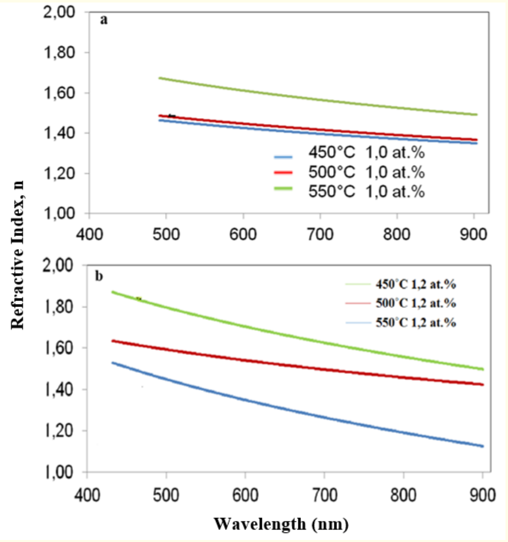

Figure 2: The changes on refractive index of the Al:ZnO films.

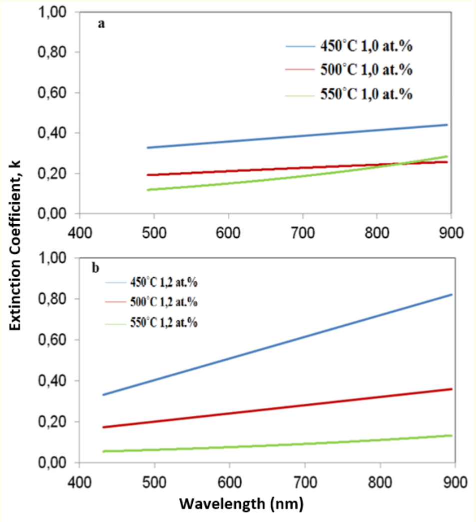

Figure 3: The variations in extinction coefficient of Al:ZnO thin film.

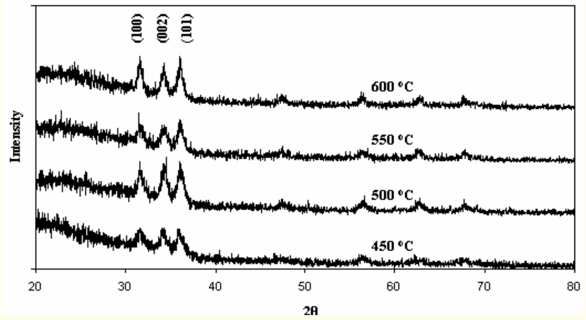

Figure 4: X-ray diffraction patterns of ZnO:Al films at different annealing temperature.

Discussions

The determination of the changes in refractive index is important for the assessment of a suitable optical parameter being directly correlated to the biomaterial density. Annealing treatment for the improvement addressed to the practical production of Al:ZnO thin films for the use in human body related with the opto-electronic systems [1]. The optical devices such as imaging/optical sensors, emissive displays contains light emitting semiconductors (for example ZnO) with higher refractive indices (> 2) than air (1.0) [2-5]. Refractive index of semiconductors is in the > 1.6 range and the 'air' side of the coating directly contacts the used environment in body and can be protective depending on antibacterial properties of ZnO in human body [6-10]. The extinction coefficient is explained the ratio of maximum to minimum transmission of a beam of light. The determination of extinction coefficient is support to make an assessment at several optometry studies the amount of the bis-retinoid N-retinylidene-N-retinylethanolamine (A2E) [11]. In this study, the determination of refractive index and extinction coefficient indicated an attention for the assessment of the suitable optical model by using Al:ZnO thin film produced by the cost effective production parameters.

Conclusions

ZnO:Al thin films samples were derived by sol–gel technique, and it was made an assessment for the optical model of ZnO:Al thin film to investigate the cost effective sol-gel coating method. The increase of refractive index depended on the increase of annealing temperature in the ZnO:Al films. The improvements of the refractive index and the increase of extinction coefficient of the thin film were performed with the rise in the annealing temperature. For the use of Al:ZnO thin film at the ophthalmic biomaterials applications related with ophthalmology and optometry services, the Al:ZnO thin film with 1.2 (at.%) Al concentration presented suitable optical model considering refractive index and extinction coefficient values after annealing temperatures at 550°C.

Acknowledgements

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