Materials Today: Proceedings 51 (2022) 1376–1380

Contents lists available at ScienceDirect

Materials Today: Proceedings

journal homepage: www.elsevier.com/locate/matpr

Structural, optical and morphological properties of pure and silver doped zinc oxide thin films by attuning the deposition layer

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A R T I C L E I N F O

Article history:
Available online 11 December 2021

Keywords:
Sol–gel
Spin-coating
Film thickness
Metal doping

A B S T R A C T

Pure Zinc oxide (ZnO) and silver doped ZnO (Ag/ZnO) thin films have potential applications in many optoelectronic devices. In this work, ZnO and Ag/ZnO thin films were prepared by a low-cost sol–gel method followed by a spin coating technique on glass substrates. Both ZnO and Ag/ZnO were spin-coated at various deposition layers (ranging from 3 to 11 deposition layers) to investigate the correlation of films' thickness on the structural and optical properties. All the prepared films were subjected to an annealing temperature of 300 °C for 1 hr. The results showed that ZnO and Ag/ZnO XRD patterns had polycrystalline wurtzite structures with (1 0 1) direction domination. On the other hand, with the addition of silver dopant, the optical properties were improved at a transmittance value greater than 90% compared to ZnO (80% transmittance). FESEM results revealed that the ZnO thin film's average grain measurement was about 65.4 nm, while Ag/ZnO exhibits grain measurement of approximately 69.3 nm. The surface morphologies showed that Ag/ZnO thin films exhibit a rougher surface due to the aggregation of silver nanoparticles. Despite the existence of agglomerated nanoparticles and higher deposition layer, the optical transmission of the Ag/ZnO is undistorted.

Selection and peer-review under responsibility of the scientific committee of the 3rd Symposium on Industrial Science and Technology 2021

1. Introduction

Indium (III) oxide (In_2O_3), indium tin oxide (ITO), and tin (II) oxide (SnO) are examples of the traditional n-type materials. Usually, they are used as transparent conducting oxide (TCO) since they are optically transparent and can conduct electricity efficiently. However, ITO has some drawbacks such as high toxicity, low stability, and very costly [1]. An alternative way to overcome the disadvantages is by selecting zinc oxide (ZnO) instead of ITO. It also inhibits high potential in many optoelectronic applications with possible alteration of its optical, electrical, and mechanical properties [2]. For instance, ZnO can be used in bipolar junction transistors, gas sensors, and coatings in solar cells, photodetectors, and light - emitting diode applications [3]. Moreover, ZnO is also known to be a promising photocatalyst for the degradation of environmental contaminants due to its high activity and excellent chemical stability [4].

Generally, ZnO thin films can be deposited by various methods, such as magnetron sputtering [5], pulsed laser deposition [6], and chemical vapor deposition [7]. These techniques were reported to produce a high crystallinity structure and a higher growth rate. Nevertheless, there are some limitations of using these techniques, such as the need for higher temperature and complex processes. Therefore, the sol–gel method seems the most prominent alternative to synthesizing the ZnO thin films due to its simple deposition equipment and ease of controlling the chemical compositions.

Nowadays, researchers have done extensive studies to investigate the effect of metal doping for zinc oxide nanoparticles [8,9]. The doping of the metallic materials is said to improve the physical performance of the doped-ZnO thin films. Among the dopants, silver (Ag) has significant properties for various photocatalytic and optical applications because it forms a shallow acceptor level for ZnO [10]. Moreover, the Ag doping in ZnO could enhance the surface charge distribution and develop conduction band acceptance during photoreaction when irradiated by UV light [11].

Based on previous researchers' continuous efforts, insufficient reports are available on the effects of structural and optical studies by various deposition layers of Ag-doped ZnO thin films in literature. Therefore, this research present the Ag-doped ZnO thin films

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https://doi.org/10.1016/j.matpr.2021.11.478

Selection and peer-review under responsibility of the scientific committee of the 3rd Symposium on Industrial Science and Technology 2021