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Short communication

ZnO and La-doped ZnO films by USP method and their characterizations for ultraviolet photodetectors and photocatalysis applications

Sabrina Roguai [a,b,*], Abdelkader Djelloul [a,b]

[a] LASPI²A Laboratory of Structures, Properties, and Interatomic Interactions, Abbes Laghrour University, Khenchela 40000, Algeria
[b] Science of Matter, Abbes Laghrour University, Khenchela, Algeria

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ABSTRACT

In this study, ZnO, Zn1-xLaxO [2, 5, 10, 15 at.%] thin films were grown on glass substrates using the spray-pyrolysis technique, to investigate the effect of doping on the structural, morphological, thermoelectric and optical properties of the layers, Also the samples were tested as UV photodetectors and photocatalyst for MB degradation. Firstly, diffraction patterns showed a hexagonal structure, with preferential grain orientation along the (002) direction, for pure ZnO and 2%La_ZnO layers, and at 5 at.% the preferential orientation changes, and crystallite sizes range from 10 nm to 19 nm. However, SEM images reveal that the ZnO and 2%La_ZnO layers are nanorods distributed over their surfaces, and the other 5%LZO, 10%LZO and 15%LZO layers characterized by nanocrystals were hexagonal prisms. The UV–visible analysis of the prepared layers shows high transparency (80–90%) in the visible range, with a constant optical gap of 3.26 eV. Thermoelectric measurements show that the ZnO and LZO layers are non-degenerate, with a maximum charge concentration of 9.18×10^{17} cm^{-3} for the 15% LZO films. The thin films show an ability for UV detection, while the 5%La_ZnO layers remain the best for UV photodetection with a good sensitivity (5.07) compared with the other layers. In terms of methyl blue degradation, the 5%La_ZnO thin films had a better degradation of 95%.

1. Introduction

Zinc oxide (ZnO) is a material with excellent properties such as a wide band gap (3.37 eV at room temperature), high exciton binding energy of 60 meV, high chemical stability, high piezoelectric constant, low dielectric constant [1]. As a result, this material can be used in gas sensors, UV light emitters, photodetectors, piezoelectric devices, solar cells and many other fields of technology [2]. The physical, optical, chemical and photocatalytic properties of ZnO can be enhanced with doping elements such as transition elements and rare earth [3]. Numerous scientific studies have focused on rare-earth-doped ZnO, with results confirming that the physico-chemical properties and transmission performance of ZnO in the visible region are enhanced by rare-earth doping. This is explained by the energy transfer between ZnO and the dopant ions, as the transition between the 4f levels make these rare earth excellent luminescence centers [4,5]. Among the rare earth, La is a good element for doping into ZnO. Thanks to their intrinsic properties of transparency and photoluminescence, transparent conducting oxides (TCOs), and ZnO in particular, are ideal as host matrices for TR ions. Lanthanum is one of the most soluble TRs, which can greatly enhance the quality of ZnO, it serves to increase oxygen vacancies [6], and consequently good polar face stability [7]. This result was recently validated by M.A. Lahmer et al [8]. Also, Sridevi et al reveal that Lanthanum doping improves the photoluminescence activity of ZnO [9]. And Xu et al.improve that the La-doped ZnO films ameliorate the optoelectronic properties, in which La in which the transmittance increase and the resistivity decrease [10].

A number of methods have been used to synthesize ZnO thin films, including RF magnetron sputtering [11], DC magnetron sputtering [12], pulsed laser deposition [13], metal organic CVD (MOCVD) [14], chemical bath deposition (CBD) [15], molecular beam epitaxy [16], spray pyrolysis [17], chemical vapor deposition [13,18], electrochemical deposition [19], sol- gel [20], screen printing [21].

In the present study, we used the ultrasonic spray pyrolysis process, a very simple, non-toxic and inexpensive method that does not require sophisticated equipment [1]. to elaborate Layers of pure and La-doped ZnO with atomic contents of 2, 5, 10 and 15% were deposited on glass substrates at 450 °C. These layers were characterized by X-ray diffraction, SEM, PL, UV–Visible spectroscopy, Seebeck coefficient, photocatalysis for methylene blue (MB) degradation and a flexible UV

* Corresponding author.
E-mail address: rog.sabrina@yahoo.fr (S. Roguai).

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