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Synthesis and characterization of spinel $ZnAl_2O_4$:SnO_2thin films for optoelectronic applications

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Introduction :

Metal oxides in thin films in general and $ZnAl_2O_4$ films in particular have potential applications in many fields, essentially when one simulates ousley needs good transparency in the visible and good electrical conductivity [1-3]. Zinc aluminate ($ZnAl_2O_4$) whose natural mineral called gahnite is a spinel oxide with cubic structure (space group Fd-3m) [1-2]. It has several advantages, such as high chemical and thermal stability, good catalytic activity, low-temperature sinter ability, and mechanical strength. In addition, it is classified as a transparent wide-bandgap semiconductor with estimated gap energy of 3.8 eV. Due to its characteristics, $ZnAl_2O_4$ is important in many technological applications such as catalysis, ceramics, aerospace, dielectrics, electronics, and optoelectronic devices [3-4]. It has been reported that the addition of metallic impurities, in the form of atoms or oxides to $ZnAl_2O_4$ adjusts both the crystallite size and the bandgap, resulting in an improvement in many properties and consequently offering greater application potential [5-7]. In this work, sol-gel process was chosen to produce the $ZnAl_2O_4$ films. It makes it possible to obtain a material of high purity having good homogeneity compared to other conventional production methods such as chemical vapor deposition, pyrolysis or spraying. X-ray powder diffractograms of pure Gahnite.

Results :

Our study highlights the following results: All diffractograms consist of a single crystalline phase with a cubic spinel structure, and they showed a preferred orientation along the (220) axis with a decrease in grain size from 32.45 nm for undoped $ZnAl_2O_4$ to 17.18 nm for $ZnAl_2O_4$ doped with 6% SnO_2. The roughness parameter reveals a decrease with thickness. The AFM studies

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revealed uniform surface and the effect of doping on the roughness of the layers has also been highlighted. We tracked the evolution of the surface roughness of the films as a function of the tin oxide content. This is due to the coalescence of grains resulting at the annealing temperature and the effect of SnO_2 on the $ZnAl_2O_4$ matrix. The UV-Visible spectra show a high transmittance in the visible light range (T ~ 98% for pure $ZnAl_2O_4$ and between 85% and 86% for all doped samples). The optical gap varies from 3.80 eV (for the undoped) to 3.68 eV for the sample doped with 6% SnO2. The infrared transmission spectra obtained for different tin dioxide doping levels show a band observed at 3599 cm^{-1}, which can be attributed to the stretching vibration of H_2O molecules. The bands at 655 cm^{-1} confirm the formation of the normal spinel structure, $ZnAl_2O_4$. Complex impedance spectroscopy indicates that the effect of grain boundaries is dominant in the conduction mechanism. It is also observed that the equivalent circuit of undoped and SnO_2-doped $ZnAl_2O_4$ films is a parallel RC circuit.

Conclusion :

Based on these results, we conclude that SnO_2 doping allows obtaining $ZnAl_2O_4$ thin films with very interesting structural and optical properties, making these films a good alternative for optoelectronic applications, such as LEDs and lasers.

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