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# Electrical and optical properties of p-type codoped ZnO thin films prepared by spin coating technique

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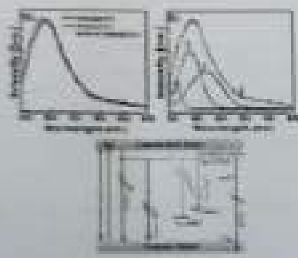
## H I G H L I G H T S

- The p-type ZnO thin films synthesized by sol-gel method.
- The average transmittance of the ZnO films is observed 83%.
- A strong UV emission was observed for ZnO thin films.
- Maximum carrier concentration is observed ~6.83 × $10^{17}$ $cm^{-3}$.

## G R A P H I C A L A B S T R A C T

Photoluminescence spectra of undoped, doped and co-doped ZnO thin film (b) De-convoluted PL curve of the undoped ZnO (c) A possible band diagram drawn from the fitted data.



## A R T I C L E I N F O

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## A B S T R A C T

Undoped, doped and codoped ZnO thin films were synthesized on glass substrates using a spin coating technique. Zinc acetate dihydrate, ammonium acetate and aluminum nitrate were used as precursor for zinc, nitrogen and aluminum, respectively. X-ray diffraction shows that the thin films have a hexagonal wurtzite structure for the undoped, doped and co-doped ZnO. The transmittance of the films was above 80% and the band gap of the film varied from 3.20 eV to 3.24 eV for undoped and doped ZnO. An energy band diagram to describe the photoluminescence from the thin films was also constructed. This diagram includes the various defect levels and possible quasi-Fermi levels. A minimum resistivity of 0.0834 Ω-cm was obtained for the N and Al codoped ZnO thin films with p-type carrier conductivity. These ZnO films can be used as a window layer in solar cells and in UV lasers.



## 1. Introduction

Zinc oxide (ZnO) is one of the most attractive II–VI group semiconductors, a versatile material having a wide band gap (3.37 eV) and a large excitation binding energy (60 meV) [1,2]. The high electron mobility, high thermal conductivity, wide and direct band gap and large excitation binding energy make ZnO stable for a wide range of applications including sensing, photo detectors, light emitting diodes and laser diodes [1–7]. ZnO is considered to be a very promising material for optoelectronic devices [1–9], particularly in the case of the next generation of inorganic light-emitting diodes and lasers [10]. ZnO appears as a potential substitute for GaN and its derivatives whose production remains costly and polluting. Unfortunately, the advent of such an innovative technology suffers from the lack of easily obtainable p–n homojunctions. Until now, producing a stable p-type ZnO remains a great challenge, and the fabrication of reliable p-type thin films is really a bottleneck, which delays the launching of ZnO based

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