# MAGNETORESISTANCE AND STRUCTURAL ANALYSIS OF MN-DOPED ZNO THIN FILMS

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**ABSTRACT:**

*The exchange effect between magnetic ions and carriers in semiconductors gives DMSs novel magneto-electric and magneto-optical properties. As a candidate material for spintronics, it has attracted increasing attention in the last 20 years.*

**KEY WORDS**

*Diluted magnetic semiconductors (DMSs) are new functional materials from doping magnetic ions in non-magnetic semiconductors.*

**INTRODUCTION.** Diluted magnetic semiconductors (DMSs) are new functional materials from doping magnetic ions in non-magnetic semiconductors. The exchange effect between magnetic ions and carriers in semiconductors gives DMSs novel magneto-electric and magneto-optical properties. As a candidate material for spintronics, it has attracted increasing attention in the last 20 years [1]. In addition, DMSs take advantage of both the charge and spin properties of electrons, making them potentially widely useful in spin field effect transistors (spin-FETs), high-density nonvolatile memory, and spin qubits for quantum computers [2]. Two main factors limit the practical application of DMSs in equipment. The first is that the Curie temperature of DMS material is lower than room temperature, and the second is whether the ferromagnetism in DMS material is intrinsic, that is, mediated by free carriers, or purely from the local secondary phase of magnetic dopants, such as clusters or precipitates. If ferromagnetism is not mediated by free carriers, spin polarization cannot be carried by them. Therefore, it is generally not suitable for spintronic devices. At present, there is only a GaMnAs confirmed ferromagnetic semiconductor with high Curie temperature. However, the highest Curie temperature is about 200 K using nanostructure engineering and is far below room temperature [3]. In the seminal paper by T. Dietl et al. [4] it was theoretically predicted a room temperature ferromagnetism (RTFM) in 5 at.% Mn-doped p-type GaN and ZnO.

In this work, structural and electrophysical properties of Mn-doped ZnO were studied. Pure ZnO and $Zn_{0.95}Mn_{0.05}O$ thin films were synthesized by ultrasonic spray pyrolysis (USP) method on Si (100). Zinc acetate and manganese acetate and thiourea were used as the zinc and manganese sources, respectively.

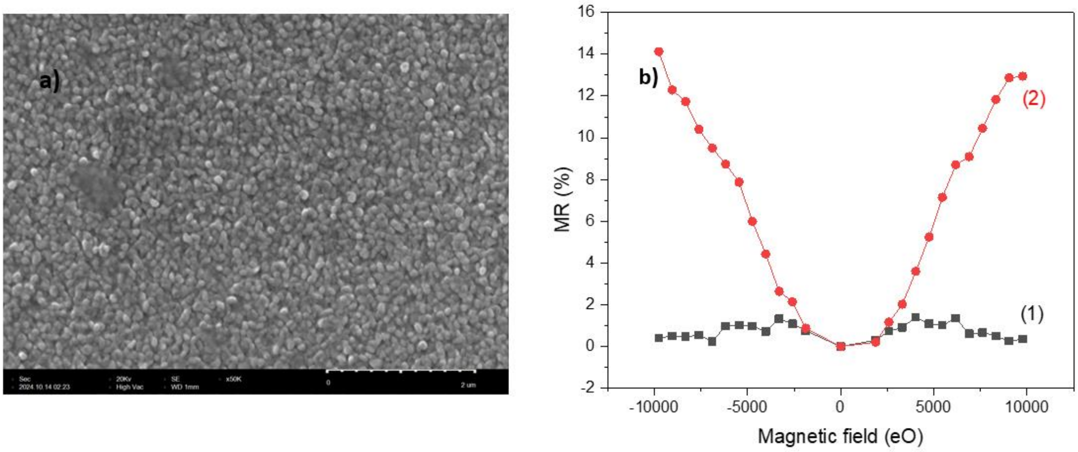


**Fig.1. a) SEM images of pure ZnO thin film and b) magnetoresistance of (1) pure and (2) Mn-doped ZnO respectively.**

In the figure 1a. shows SEM (Scanning electron microscope ) image of pure ZnO. At the surface of the thin film, nanocrystals can be seen, and the size of nanocrystals was approximately 100 nm. The thickness of Mn-doped and pure ZnO films was about 200 nm. In Figure 1b., magnetoresistance results of the ZnO (1) and ZnMnO (2) were given respectively. The magnetoresistance (MR) was calculated by $MR = \frac{R(H)-R(0)}{R(0)}100\%$ at room temperature. The current was 40 mkA for both measurements.

In conclusion, polycrystalline ZnO and 5 % Mn-doped ZnO were synthesized by ultrasonic spray pyrolysis method on a Si substrate. The morphology of the deposited films was studied. The magnetic field dependence of the resistances of the sample was measured at room temperature. And, the resistance change under different magnetic fields for the pure ZnO showed almost no response. While the manganese-doped zinc oxide gave huge positive magnetoresistance because of the magnetic dopant.

**References:**

[1] S. A. Wolf, et al., Science 294 (2001) pp.1488-1495.
[2] S. J. Pearton, et al., Journal of Applied Physics 93 (2003) pp. 1-13.
[3] Lin Chen, et al., Nano Letters 11 (2011) pp. 2584–2589.
[4] T. Dietl, et al., Science 287 (2000) pp. 1019-1022.