Structural, Optical, and Magnetic Properties of Mn Doped ZnO Thin Films

A. M. Alsmadi[1*] and B. Salameh[1]

[1]Department of Physics, Kuwait University, 13060 Safat, Kuwait,
*E-mail address: abdel.alsmadi@ku.edu.kw

Abstract

Zinc oxide (ZnO) is an extensively studied semiconductor due to its versatile properties applicable to many technologies, including optoelectronics and spintronics [1, 2]. The theoretical prediction and experimental observation of room temperature ferromagnetism in Mn doped ZnO has sparked the research and opened up the possibility to use these diluted magnetic semiconductors in future spintronics technologies [3, 4]. In this study, we prepared Mn-doped ZnO films with varying Mn content using ultrasonic spray analysis technique, and carried out a systematic study on their structural, electronic, magnetic, and photoluminescent properties. The x-ray absorption spectroscopy (XAS) and x-ray photoelectron spectroscopy (XPS) results indicated the incorporation of Mn dopants into the ZnO lattice and confirm the presence of Mn atoms in Mn^{2+} state. The incorporation of Mn ions into the ZnO lattice was also confirmed by the Fourier transform infrared and Ultra Violet–visible spectroscopy results. XPS and x-ray diffraction (XRD) analysis with full structural Rietveld refinement revealed that all ZnO films with different Mn doping possessed typical wurtzite structure and had no other impurity phases. Furthermore, the XPS results indicated a reduction in the oxygen vacancies concentration with increasing the Mn doping level. The Photoluminescence results provided evidence for several types of defects in the doped films and a reduction in the concentration of the defects responsible for the deep level emission. The magnetization measurements showed a weak ferromagnetic behavior at room temperature and a clear ferromagnetic behavior at low temperature in all Mn doped films. The ferromagnetic order is improved by increasing the Mn doping and we found a strong correlation between the ferromagnetic order and the concentration of oxygen vacancies in the doped films.

[1] V. Avrutin, et al., Proc. IEEE **98**, 1269 (2010)
[2] S. A. Wolf, et al., Science **294**, 1488, (2001)
[3] T. Dietl, et al., Science **287**, 1019H, (2000)
[4] M. Shatnawi, et al., Results in Physics **6**, 1064 (2016)