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Enhanced ferromagnetic properties of diluted Fe doped ZnO with an Al co-doping

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Al-added $Zn_{0.99-x}Fe_xAl_{0.01}O$ (x = 0, 0.02, 0.05) powders were prepared with an annealing in an Ar atmosphere at 1200 °C. All the peaks from the X-ray diffraction patterns of the samples belonged to the hexagonal ($P6_3mc$) lattice of ZnO, and no indication of a secondary phase was found. The lattice parameters for the $Zn_{0.94}Fe_{0.05}Al_{0.01}O$ were a_0 = 3.254 Å and c_0 = 5.209 Å at room temperature. The hysteresis curve for the $Zn_{0.94}Fe_{0.05}Al_{0.01}O$ at room temperature revealed a ferromagnetic phase. The temperature dependency of the magnetization curve was measured from 60 to 350 K and revealed that the Curie temperature was above room temperature. In this study we demonstrated an enhanced ferromagnetic behavior due to an electric property change with an Al co-doping effect.

1 Introduction

Diluted magnetic semiconductor is expected to play an important role in interdisciplinary materials science and future electronics because the charge and spin degrees of freedom are accommodated into a single matter resulting in interesting magnetic, magneto-optical, magneto-electronic, and other properties [1–4]. Since the discovery of ferromanetism at room temperature in Mn-doped ZnO [3], numerous experimental and theoretical investigations have been performed on the magnetic properties and the related structural and electronic properties of transition-metal-doped ZnO. The presence of magnetic ions such as *3d* transition metal ions in these materials leads to an exchange interaction between the itinerant *sp* band electrons or holes and the *d* electron spins localized at the magnetic ions, resulting in versatile magnetic field induced functionalities. The energy structure of the unoccupied electronic states is of particular interest as these states are very sensitive to the local bonding environment, such as the number of valence electrons, their spin configuration and the coordination number of the structural unit cell. Among them, II–VI semiconductors have an advantage, where the concentration of a charge and spin can be controlled independently by changing the concentrations of the dopant elements for injecting the carriers and the transition metal elements (Mn, Co, and Fe etc.) [5–7].

In the present work, the magnetic and electronic properties of $Zn_{1-x}Fe_xO$ co-doped with Al have been investigated by X-ray diffraction (XRD), vibrating sample magnetometer (VSM), Hall effect, and Mössbauer spectroscopy mesurments. Large magnetic moments were observed at room temperature from the present Al co-doped $Zn_{1-x}Fe_xO$. The change of the magnetic properties of the oxides related to the electronic properties was examined.

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