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Structural and magnetic properties of Fe-doped ZnO thin films

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We present the structural and magnetic properties of $Zn_{1-x}Fe_xO$ films with Fe composition ratio of 0.03 ~ 0.07. High-quality Fe-doped ZnO thin films with thickness of 500nm were fabricated on α-sapphire [0001] substrates by RF magnetron sputtering. The structures of $Zn_{1-x}Fe_xO$ thin films with different Fe composition ratio were studied with various measurements. The x-ray diffraction (XRD) measurements showed that the $Zn_{1-x}Fe_xO$ films (x = 0.03, 0.05, 0.07) had a wurtzite structure without any extra phase. However, the (0002) diffraction peak gradually shifted from $2\Theta = 34.42°$ to 34.1° as x was increased from 0.03 to 0.07. This means that the lattice constant c was increased by about 0.047 Å due to Fe replacement on the Zn site in the $Zn_{1-x}Fe_xO$ films. X-ray absorption fine structure (XAFS) studies of the structural environments around Zn and Fe atoms in $Zn_{1-x}Fe_xO$ thin films confirmed the substitution of Fe atoms on the Zn sites. X-ray photoelectron spectroscopy (XPS) measurements were employed to characterize the valence state of the Fe ions. The XPS measurements showed coexistence of Fe^{3+} and Fe^{2+} ions. Basing on the XAFS and XPS results, we could rule out the possibility of existing Fe metal clusters in the $Zn_{1-x}Fe_xO$ films. We also studied the magnetic properties of the films with DC-magnetization measurements.