Structural Phase Transition, Electronic Structure, and Magnetic Properties of Sol-gel-prepared Inverse-spinel Nickel-ferrites Thin Films

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X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), and vibrating sample magnetometry (VSM) were used to investigate the influence of Ni ions on the structural, electronic, and magnetic properties of nickel-ferrites (Ni_xFe_{3-x}O₄). Spinel Ni_xFe_{3-x}O₄ ($x \le 0.96$) samples were prepared as polycrystalline thin films on Al₂O₃ (0001) substrates, using a sol-gel method. XRD patterns of the nickel-ferrites indicate that as the Ni composition increases (x > 0.3), a structural phase transition takes place from cubic to tetragonal lattice. The XPS results imply that the Ni ions in Ni_xFe_{3-x}O₄ substitute for the octahedral sites of the spinel lattice, mostly with the ionic valence of +2. The minority-spin *d*-electrons of the Ni²⁺ ions are mainly distributed below the Fermi level (E_F), at around 3 eV; while those of the Fe²⁺ ions are distributed closer to E_F (~1 eV below E_F). The magnetic hysteresis curves of the Ni_xFe_{3-x}O₄ films measured by VSM show that as x increases, the saturation magnetization (M_s) linearly decreases. The decreasing trend is primarily attributable to the decrease in net spin magnetic moment, by the Ni²⁺ (2 µ_B) substitution for octahedral Fe²⁺ (4 µ_B) site.

Keywords: nickel-ferrite, spinel, phase transition, magnetization