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Magnetic Properties of $Sn_{1-x}Fe_xO_2$ Thin Films and Powders Grown by Chemical Solution Method

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Since the discovery of ferromagnetism in Co-doped TiO_2 at room temperature[1], numerous experimental and theoretical investigations about transition metal doped semiconductor have been performed on the magnetic properties[2,3]. This work is an experimental investigation at the effects of iron doping on the structural and magnetic properties of tin oxide. Among the various transition metal additives, Fe is of special interest because of its capability of grain growth inhibition within the SnO_2 metrix[4]. Pure and iron-doped $Sn_{1-x}Fe_xO_2$ (x=0, 0.1, 0.2, 0.33) thin films on Si(100) substrates and powders have been successfully prepared by means of chemical solution process and they were annealed at 300, 400, 500, 600, and 700℃. The XRD patterns of $Sn_{1-x}Fe_xO_2$ thin films and powders show rutile tetragonal structure with a_0 = 4.732 Å, c_0= 3.165 Å for x=0.33. In x-ray diffraction (XRD) measurement, rutile-structure phase peaks of $Sn_{1-x}Fe_xO_2$ begins to appear in the sample annealed at 500℃, the phase is fully developed over 700℃, and no impurity phase were observed, which indicates the highly homogeneous nature of the developed phase. TG and DTA analysis were conducted on powder xerogel up to 1000℃ at a heating rate of 5℃/min. TGA analysis indicated a major weight loss step between 170℃ and 250℃, and a smaller weight loss in the range of 270-340℃, the final weight loss was completed at 410℃. The gel exhibited approximately 50% weight loss in the temperature range of 100℃ to 400℃. AFM images for $Sn_{1-x}Fe_xO_2$ thin films indicated the surface of thin films were composed of uniformly distributed grains. Magnetic properties were characterized by vibrating sample magnetometer (VSM). The thin films with x=0.1 and 0.2 showed paramagnetism, but for the film and powder with x=0.33 ferromagnetism was observed at room temperature. The ferromagnetism in samples can be interpreted in terms of a direct ferromagnetic coupling of ferric ions via an electron trapped in a bridging oxygen vacancy (*F* center). This result clearly indicates that the $Sn_{1-x}Fe_xO_2$ thin films (x=0.33) are advantageous for practical application in magnetic semiconductor device.

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