MÖSSBAUER STUDY ON INDIUM TIN OXIDES DOPED WITH Fe

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Magnetic interactions in diluted magnetic semiconductors are of great interest from the points of view of both science and technology application such as spintronics. The doping of semiconductors with transition metal ions can induce ferromagnetism. Room temperature ferromagnetism was observed for differently prepared Fe doped SnO2 [1-3]. In the Sn1-xFe2O3 sample with x = 0.1, annealed at 500°C, the ferromagnetism was clearly observed at room temperature although its Mössbauer spectrum did not show any magnetic component, but only two paramagnetic doublets between 10K and 300K [3]. It was recently reported that ITO films (In:Fe:Sn= 2.0:0.15:0.05) prepared by PLD also show room temperature magnetism [4]. Indium and tin oxide (ITO) is widely used as transparent electrode films. We have studied on tin doping effect in ITO powders and films by 119Sn Mössbauer spectroscopy [5]. In this study, Indium oxide powders co-doped with different contents of Sn and Fe have been prepared by a sol-gel method. It is found that some samples showed the ferromagnetic properties.

Samples of In1-xSnFe2 mixed oxides (y=0.03, 0.06, and 0.12, x=0.005-0.15) were prepared by a sol-gel method using In(CH3COOH), Sn(CH2COCH2COCH3)4 and Fe nitrate solution, and annealed at 200°C for 1 hour, and at 400°C for 2 hours, 550°C for 4 hours and 600°C for 4 hours. The powders obtained were measured by a vibration sample magnetometer (VSM) and a transmission Mössbauer spectrometry.

Fig. 1 shows a typical VSM magnetization curve of (In0.88Sn0.06Fe0.06)2O3, which indicates room temperature ferromagnetism although the magnetic hysteresis contains paramagnetic components. The sample (x=0.06) with y=0.03 showed a very weak ferromagnetism, whereas the sample (x=0.06) with y=0.12 showed paramagnetism. Mössbauer spectra of these samples were shown in Fig. 2. The area intensity of magnetic relaxation peaks (y=0.06 : 11%, y=0.03 : 7%, and y=0.12 : <5%) was consistent with the ordering of saturation magnetization. Two paramagnetic doublets (D1: \( \delta = 0.36 \text{ mm/s}, \Delta = 0.76 \text{ mm/s} \) and D2 (\( \delta = 0.31 \text{ mm/s}, \Delta = 1.50 \text{ mm/s} \)) were observed. The Fe\(^{3+} \) species (D1) occupy d site of bixbyite structure, and the other species (D2) occupy b site. The area intensity ratio of each doublet for samples with y=0.03 and y=0.06 was consistent with the ratio of d/ b site occupations (24/8), whereas the area intensity ratio of sample with y=0.12 was less than 3/1. Fe species can substitute the d and b sites uniformly for samples doped upto 6% Sn, but with the more increase of Sn concentrations, Sn can not be substituted perfectly at In2O3 lattice, and may affect the Fe substitution. Therefore, the magnetization may be reduced for sample with y=0.12. These results will be discussed in terms of magnetic interactions as an effect of the doping.

References