

Room-Temperature Ferromagnetism in Anatase $\text{Ti}_{1-x}\text{Fe}_x\text{O}_{2.8}$ Thin Films

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Recently, there have been a large number of investigations on semiconducting oxides that exhibit ferromagnetism with high Curie temperature above 300 K. Such diluted magnetic semiconductors are achieved by doping 3d transition-metal elements such as V, Mn, Fe, Co, and Ni into base oxides such as ZnO, SnO₂, and TiO₂.

In the present work, magnetic and electronic properties of Fe-doped anatase TiO_{2.8} thin films grown on Al₂O₃(0001) substrates by a sol-gel method have been investigated by vibrating-sample magnetometry (VSM), conversion electron Mössbauer spectroscopy (CEMS), and Hall effect measurements.

Anatase $\text{Ti}_{1-x}\text{Fe}_x\text{O}_{2.8}$ thin films were found to exhibit ferromagnetism at room temperature by VSM. The saturation magnetic moment of the ferromagnetic films are ~ 2 and $\sim 1.5 \mu_B$ per Fe ion for $x = 2.4$ and 5.8 at.%, respectively, as shown in Fig. 1. The isomer shifts in CEMS measurements as shown in Fig. 2, are 0.26–0.28 mm/s, indicating a ferric character. The Mössbauer spectra also revealed that Fe^{3+} ions mostly substitute the octahedral Ti^{4+} sites of $\text{Ti}_{1-x}\text{Fe}_x\text{O}_{2.8}$. The $\text{Ti}_{1-x}\text{Fe}_x\text{O}_{2.8}$ films exhibited poor electrical conductivity with *p*-type character. The ferromagnetism in the present $\text{Ti}_{1-x}\text{Fe}_x\text{O}_{2.8}$ films can be interpreted in terms of a direct ferromagnetic coupling between two neighboring Fe^{3+} ions via an electron trapped in oxygen vacancy [1]. The reduction of the net magnetization by the increase of the Fe content in the film can be explained in terms of an antiferromagnetic superexchange interaction between two neighboring Fe^{3+} ions via O^{2-} ion.

Reference

[1] J. M. D. Coey, A. P. Douvalis, C. B. Fitzgerald, and M. Venkatesan *Appl. Phys. Lett.* **84**, 1332 (2004).

This work was supported by grant No. R01-2003-000-10293-0 from the Basic Research Program of the Korea Science & Engineering Foundation

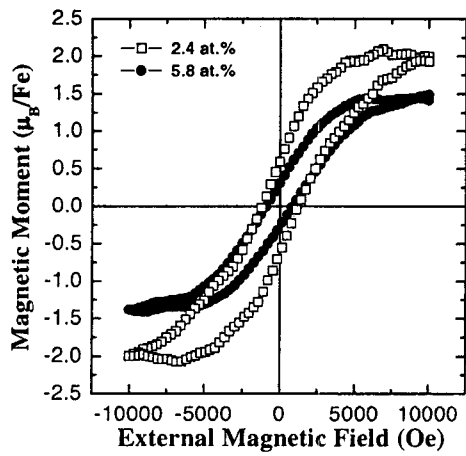


Fig. 1. Room-temperature VSM measurement result of anatase $\text{Ti}_{1-x}\text{Fe}_x\text{O}_{2-\delta}$ ($x = 2.4$ and 5.8 at.%) films.

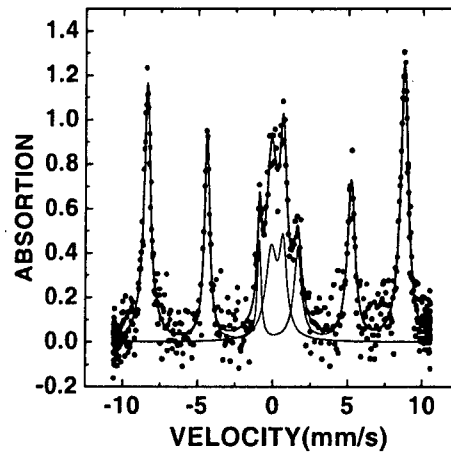


Fig. 2. CEMS spectrum of $\text{Ti}_{1-x}\text{Fe}_x\text{O}_{2-\delta}$ ($x = 5.8$ at.%) film measured at room temperature