INTERMAG ASIA 2005:
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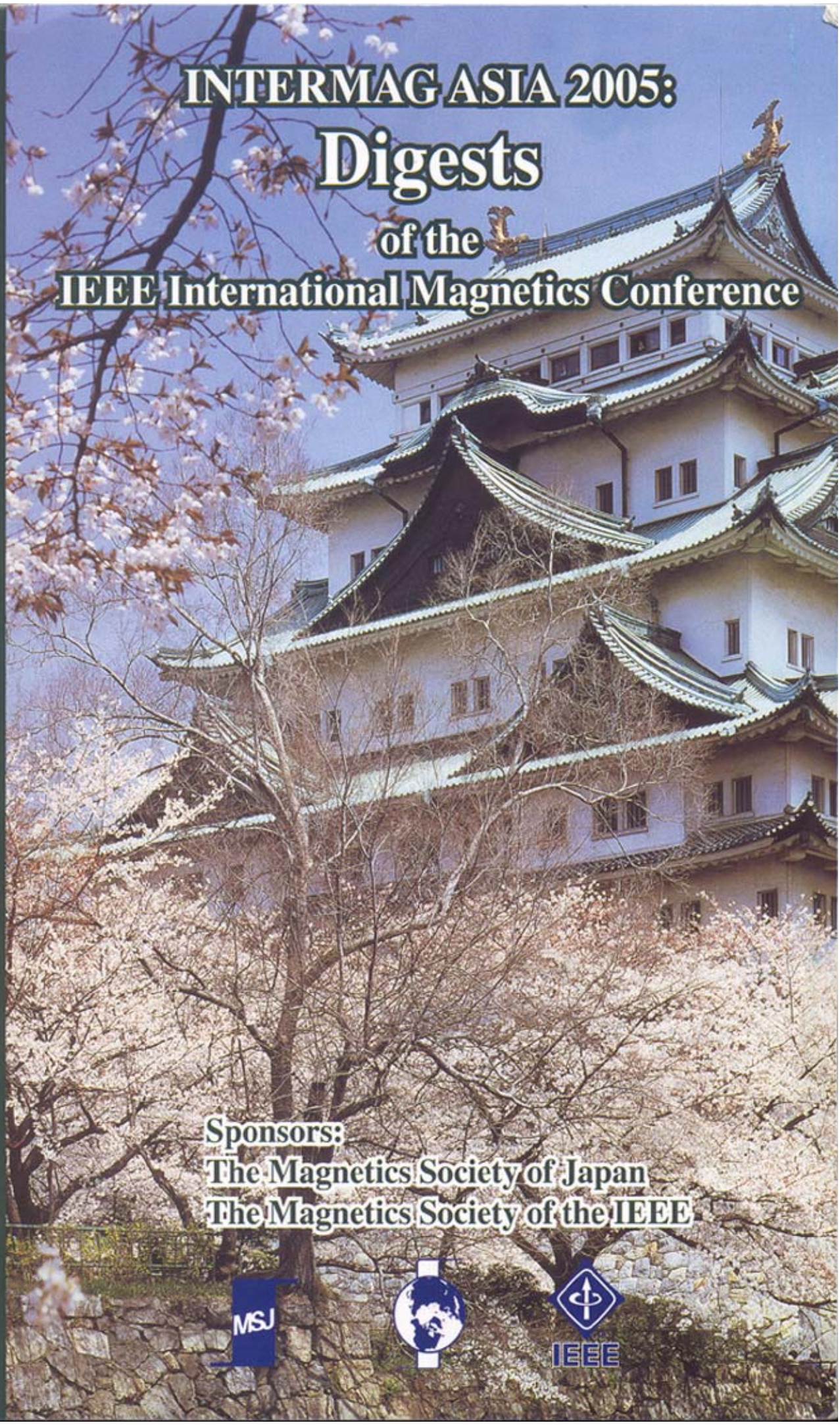
of the
IEEE International Magnetics Conference

The 2005 IEEE International Magnetics Conference
April 4 – 8, 2005 • Nagoya Congress Center • Nagoya, Japan



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DILUTED FERROMAGNETIC PROPERTIES IN Fe- and Co-DOPED $TiO_{2-\delta}$ THIN FILMS

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Introduction

It have been reported a lot of study focused on oxide materials that show ferromagnetism with higher Curie temperature compared to existing III-V and II-VI semiconducting compounds. Recently, TiO_2 doped with transition-metal elements such as Fe, Co, and Ni were found to exhibit ferromagnetism above room temperature. Although such diluted magnetic semiconductors (DMSs) have been under remarkable attention recently, the results reported by different research groups are frequently controversial on the origin of the exhibited ferromagnetic properties.[1]

Experimental

In this work, magnetic and electronic properties of Fe- and Co-doped $TiO_{2-\delta}$ thin films were investigated by vibrating sample magnetometer (VSM), Mössbauer spectroscopy, X-ray photoelectron spectroscopy (XPS), and Hall measurements. Anatase TiO_2 thin films were deposited on $Al_2O_3(0001)$ substrates by a sol-gel method employing spin-coating process. The precursor solution was prepared by dissolving titanium butoxide, $Ti[O(CH_2)_3CH_3]_4$, in 2-methoxyethanol at 70 °C.

Results and Discussions

When the precursor films were annealed in air, the resultant TiO_2:Fe and TiO_2:Co films were found to become electrically insulating. Also, no ferromagnetic properties were observed in those films. On the other hand, when the precursor films were annealed in vacuum, the resulting oxygen-deficient $TiO_{2-\delta}$:Fe and $TiO_{2-\delta}$:Co films were found to become semiconducting with p-type carriers in the 10^{18} cm^{-3} range obtained by Hall measurements. The oxygen-deficient films go through conductivity transition from n-type to p-type by Fe and Co doping. The results of VSM measurements on these $TiO_{2-\delta}$:Fe and $TiO_{2-\delta}$:Co films are shown in Fig. 1, exhibiting ferromagnetic behavior at room temperature. Such ferromagnetic properties are found to disappear for highly Fe- or Co-doped films. XPS measurements on the Fe- and Co-doped $TiO_{2-\delta}$ films reveal that Fe ions have both Fe^{2+} and Fe^{3+} ionic valences while Co ions have Co^{2+} mostly, as shown in Fig. 2. Density of Fe^{2+} ions is found to be reduced after annealing. Mössbauer spectroscopy measurements on $TiO_{2-\delta}$:Fe films also reveal the change of the magnetic properties with Fe composition and no possibility of Fe clusters in our thin film.

Reference

[1] H. M. Lee, S. J. Kim, I. Shim, and C. S. Kim, IEEE Trans. Magn. **39**, 2788(2003).

0-7803-9009-1/05/$20.00 ©2005 IEEE

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

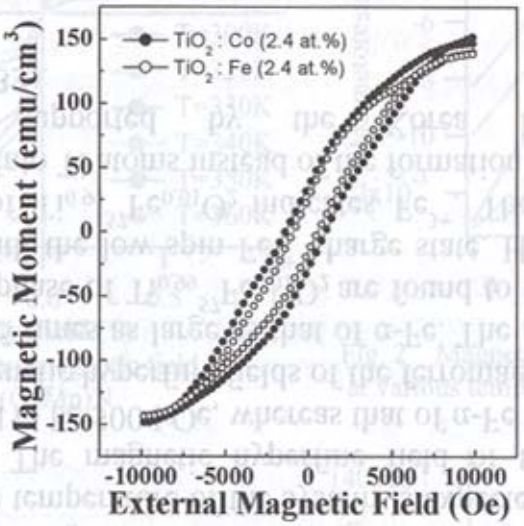

Fig. 1. Results of VSM measurements on anatase TiO_2:Fe and TiO_2:Co films with Fe and Co concentration of 2.4 at.%.

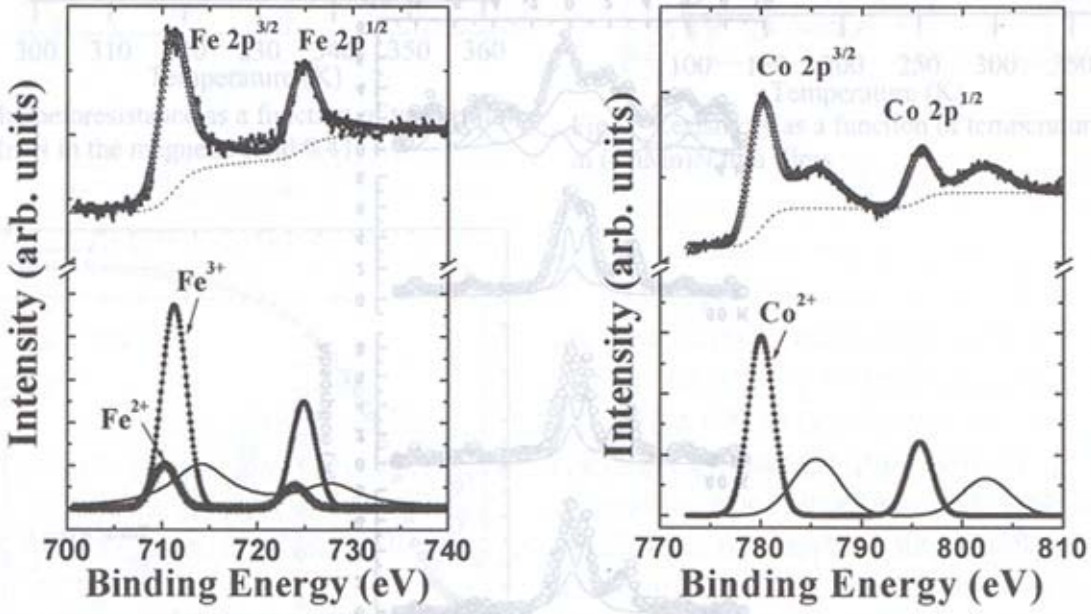

Fig. 2. Results of XPS measurements on TiO_2:Fe and TiO_2:Co films with Fe and Co concentration of 12 and 15 at.%, respectively.