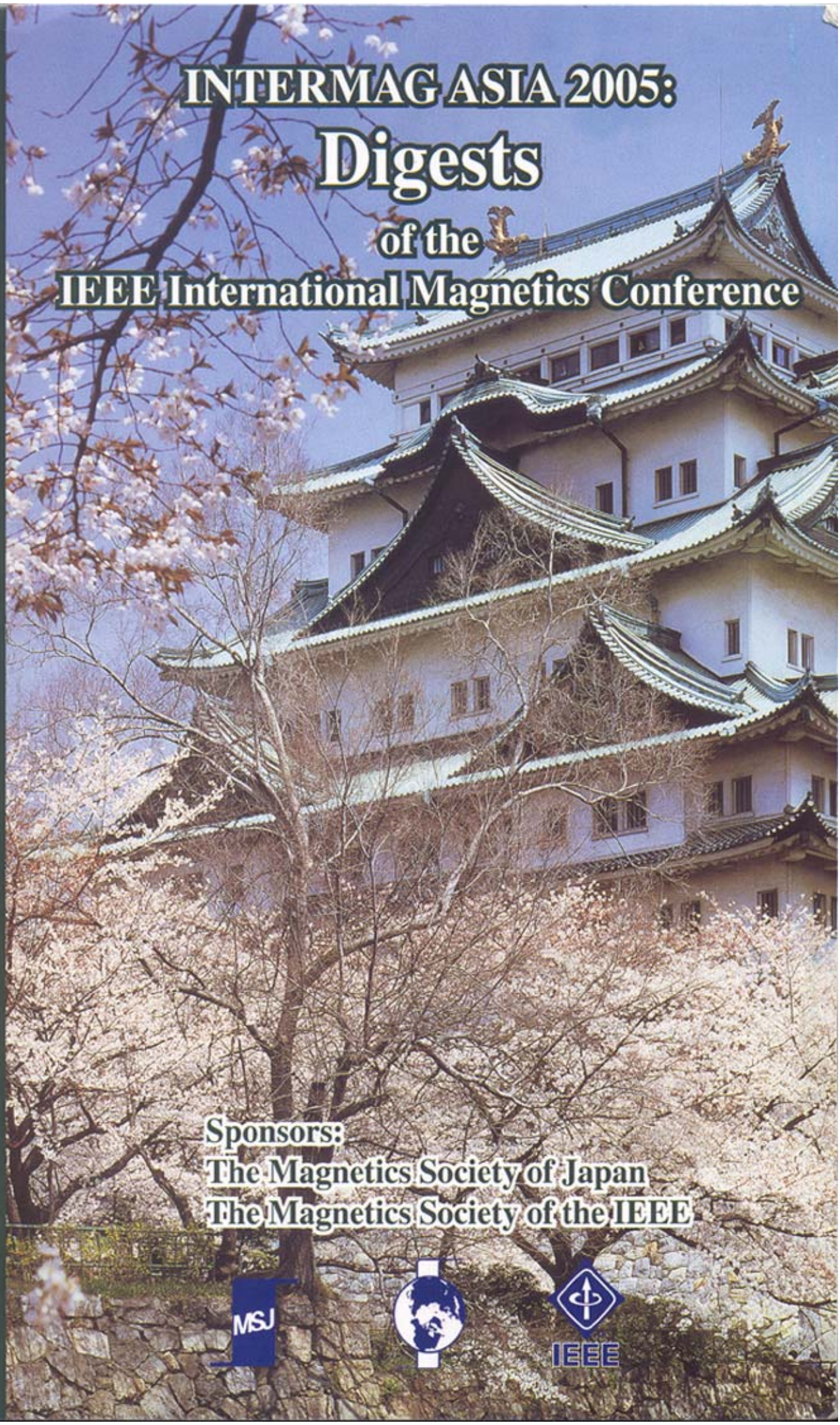
INTERMAG ASIA 2005:
Digests
of the
IEEE International Magnetics Conference

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



Sponsors:
The Magnetics Society of Japan
The Magnetics Society of the IEEE

MSJ

IEEE

LOW TEMPERATURE HYDROGEN TREATMENT OF Fe DOPED ZnO FERROMAGNETIC SEMICONDUCTOR

Geun Young Ahn[1], Seung-Iel Park[1], Sam Jin Kim[1], Bo Wha Lee[2], and Chul Sung Kim[1]

(1) Dept. of Physics, Kookmin University, Seoul 136-702, Korea (2) Dept. of Physics, Hankuk University of Foreign Studies, Kyungki 449-791, Korea

Introduction

The transition-metal doped ZnO has drawn much attention for the suggested possibility of room temperature ferromagnetism in ZnO-based diluted magnetic semiconductor (DMS) [1]. Doping of transition metal in ZnO leads to new interesting properties [2]. Among them, II–VI semiconductors have an advantage, where charge and spin can be controlled independently by changing the concentrations of dopant elements injecting carriers and the transition metal element(Mn, Co, Fe etc.), respectively [3]. In spite of numerous studies carried out on this type of DMS, no practical application of these materials has been realized. The feature that has hampered application has been the low Curie transition temperature of DMS materials. In this paper, we report ferromagnetism of $Zn_{1-x}Fe_xO$ powder at room temperature, fabricated by sol-gel method. Specially, we have used hydrogen treatment to control of phase separation. Hydrogen treatment of sol-gel process has an advantage to easy control compositions and low annealing temperature. This process enhanced a of strong ferromagnetic behavior compare with transition metal doped ZnO by a solid-state reaction [4].

Experimental

The $Zn_{1-x}Fe_xO$ (x=0.00, 0.01, 0.03, 0.05, 0.07, 0.10) compounds were fabricated using the sol-gel method. Weighed amounts of zinc acetate $(CH_3CO_2)_2Zn$ and iron acetate $(CH_3CO_2)_2Fe$ were first dissolved in 2-methoxyethanol, acetic acid, and water. All reactions were carried out under dry nitrogen in a glove box. The solution was refluxed at 80 ℃ for 12 h to allow the gel formation and then dried at 200 ℃ for 24 h. The dried powder was grounded and annealed at 650 ℃ for 6 h in H_2 5%/Ar bal. gas atmosphere. The crystal structures of the samples were examined by X-ray diffraction (XRD) with CuKα radiation. Magnetic and electric properties were characterized by using a vibrating sample magnetometer (VSM) and an applied field dependence of resistance.

Results and discussions

The X-ray diffraction(XRD) patterns show that the doping of iron does not change the wurzite structure of ZnO for doping concentrations below x = 0.07. Furthermore, we could not find any Fe cluster or phase separation in the XRD measurements. Above the x = 0.10, some secondary peaks(●) appeared, which were defined as phase separation of FeO. We have presented the observed and calculated peak profile, and Bragg position of a typical X-ray diffraction pattern for $Zn_{1-x}Fe_xO$ (x=0.01, 0.07, 0.10) in Fig. 1. The crystal structure of $Zn_{0.99}Fe_{0.01}O$ at room temperature is determined to be a hexagonal structure of

0-7803-9009-1/05/$20.00 ©2005 IEEE

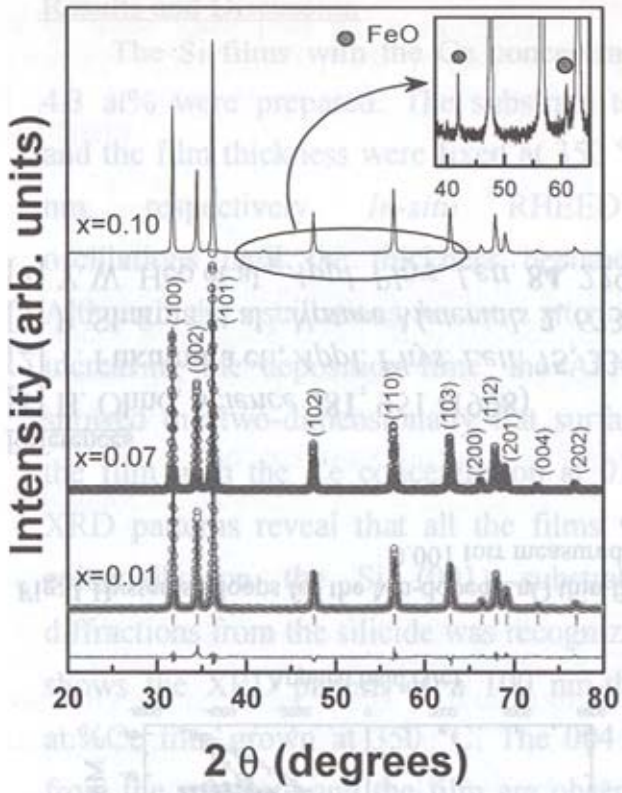


Fig. 1. Refinded X-ray diffraction patterns of $Zn_{1-x}Fe_xO$ (x=0.01, 0.07, 0.10) at room temperature.

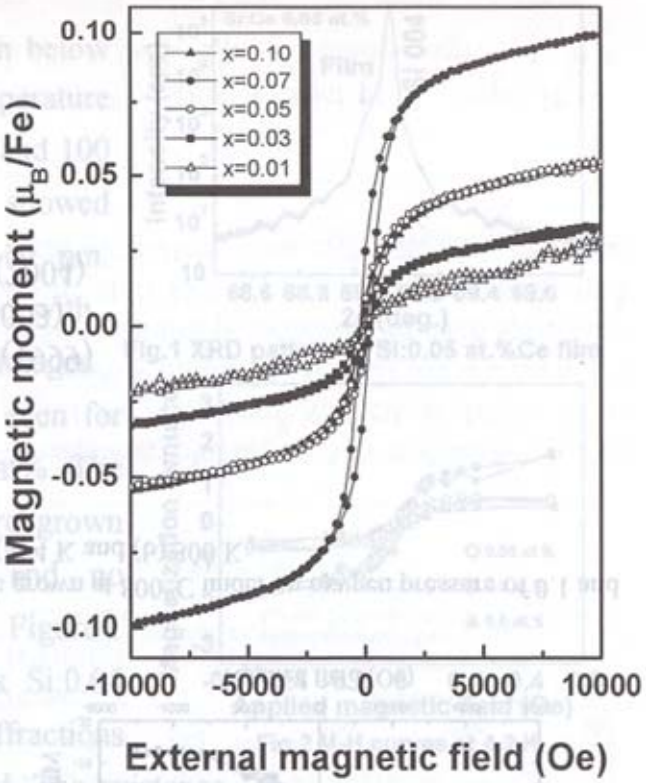


Fig. 2. M-H loops of $Zn_{1-x}Fe_xO$ (x=0.01, 0.03, 0.05, 0.07, 0.10) at room temperature.

$P6_3mc$ with its lattice constants a_0 = 3.2494 □ and c_0 = 5.2031 □ by Rietveld refinement. The determined Bragg factors R_B and R_F were 4.61 and 4.28%, respectively. No appreciable difference in the lattice parameters has been observed for the Fe-doped $Zn_{1-x}Fe_xO$. Figure 2 shows magnetic hysteresis loops at room temperature for $Zn_{1-x}Fe_xO$ with various Fe concentrations. As shown in this figure, an obvious ferromagnetic behaviour is shown for all samples with the coercivity (H_C) of 200 ~ 220 Oe. It is noteworthy that the magnetic moment per Fe atom increased until the x=0.07 with increase x, however, it showed a decreased result in the x=0.10, as shown in Fig. 2. This phenomena can be explained by decrease of Fe ions which contribute to Zn(Fe)O, and it is closely related to the low antiferromagnetic Néel temperature for the second phase of FeO (~210 K).

References

[1] T. Dietl, H. Ohno, F. Matsukura, J. Cibert, D. Ferrand, Science 287, 1019 (2000)
[2] X. M. Cheng and C. L. Chien, J. Appl. Phys. 93, 7876 (2003)
[3] S. J. Pearton, C. R. Abernathy, M. E. Overberg, G. T. Thaler, D. P. Norton, N. Theodoropoulou, A. F. Hebard, Y. D. Park, F. Ren, J. Kim, and L. A. Boatner, J. Appl. Phys. 93, 1 (2003)
[4] H. Lin, T. Chin, J. Shin, S. Lin. T. Hong, R. Huang, F. Chen, and J. Kai, Appl. Phys. Lett. 85, 621 (2004)