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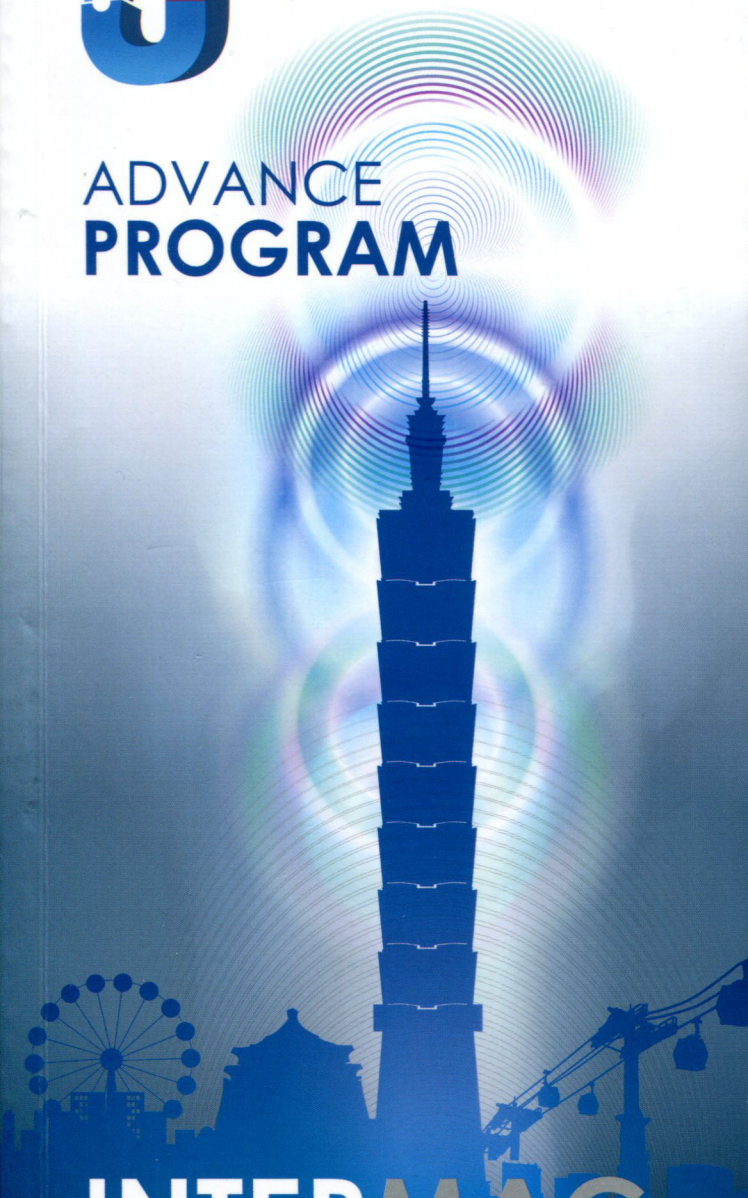

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Applied-field dependent hyperfine structure and magnetic properties of $Ni_{0.8-x}Cu_xZn_{0.2}Fe_2O_4$

Y. Li[1], S. An[2], C. Kim[1]
1. Department of Physics, Kookmin University, Seoul, Republic of Korea; 2. LCR division, Samsung Electro-Mechanics, Suwon, Republic of Korea

Introduction

Nickel-copper-zinc ferrites are interesting magnetic materials for multilayer chip inductor (MLCI) applications, which is due to the fact that these ferrites have high electrical resistivity, permeability, and low sintering temperature[1, 2]. Moreover those, Nickel-copper-zinc ferrites have interesting physical properties as a non-collinear magnetic structure. One feature making an investigation of the Ni-Cu-Zn ferrites especially noteworthy is the difference in cation distributions. Either the Zn^{2+} ions occupy only *A* sites, having a normal spinel structure, or Ni^{2+}, Cu^{2+} ions are only at *B* sites, forming the inverse spinel structure.

In this paper, we investigated applied-field dependent magnetic hyperfine structure of Ni^{2+}, Cu^{2+}, and Zn^{2+} ions for $Ni_{0.8-x}Cu_xZn_{0.2}Fe_2O_4$ as well as corresponding magnetic spin structure with applied-field Mö ssbauer spectroscopy.

Experiments

Single phased of polycrystalline $Ni_{0.8-x}Cu_xZn_{0.2}Fe_2O_4$(x = 0.2, 0.4, 0.6) was synthesized by the solid-state reaction method. NiO (99.99%), ZnO (99.99%), CuO (99.99%) and α-Fe_2O_3 powder (99.995%) were starting materials. These were mixed and annealed at 1000 ^oC for 24h in air. The identification of the crystal structure and determination of lattice constant were carried out by x-ray diffraction (XRD). The microstructure and morphology of the prepared sample were examined by a field emission scanning electron microscope (FE-SEM). Magnetic properties were measured by a vibrating sample magnetometer (VSM) and applied-field Mö ssbauer spectrometer, using a ^{57}Co (Rh) source in a constant acceleration mode. In order to separate sublattice lines, Mö ssbauer spectra were taken in the presence of an external magnetic field under 5 T parallel to the γ-ray direction at 4.2 K.

Results and discussion

The crystal structure of $Ni_{0.8-x}Cu_xZn_{0.2}Fe_2O_4$(x = 0.2, 0.4, 0.6) was determined by Rietveld FULL-PROF program. The Zn^{2+} and iron ions occupy *A* sites, and Ni^{2+}, Cu^{2+}, iron ions occupy *B* sites, forming $(Zn_{0.2}Fe_{0.8})^A[Ni_{0.8-x}Cu_xFe_{1.2}]^BO_4$(x = 0.2, 0.4, 0.6). The crystal structure was determined to be a cubic spinel with space group *Fd*-3m. The lattice constant a_0 increases from 8.373 to 8.373 Å with increasing Cu concentration. The magnetic hysteresis loop of $Ni_{0.8-x}Cu_xZn_{0.2}Fe_2O_4$ powders at room temperature with various Cu concentrations. The saturation magnetization (*M*s) and coercivity (*H*c) under the applied-field of 10 kOe, were 57.5 emu/g and 38 Oe for x = 0.2 sample, and 52.8 emu/g and 13 Oe for x = 0.6 sample, respectively, as shown Fig. 1. FE-SEM image of the $Ni_{0.8-x}Cu_xZn_{0.2}Fe_2O_4$(x = 0.2, 0.4, 0.6) for morphology of the synthesized particles shows irregular shape and an inhomogeneous microstructure with discontinuous gain growth. According to the probability of distribution, we have analyzed Mö ssbauer spectra as 5 sets with six-lines at 4.2 K. Applied-field Mö ssbauer spectra of the $Ni_{0.8-x}Cu_xZn_{0.2}Fe_2O_4$(x = 0.2, 0.4, 0.6) were measured with parallel to the γ-ray direction under 5 T at 4.2 K, as shown Fig. 2. Hyperfine fields of A and B sites at 5 T was $H_{hf}(A)$ = 521 kOe, average $\langle H_{hf}(B)\rangle$ = 447 kOe for x = 0.2 sample, and $H_{hf}(A)$ = 510 kOe, $\langle H_{hf}(B)\rangle$ = 440 kOe for x = 0.6 sample, respectively. Also, the second and fifth absorption lines of Mö ssbauer spectra were completely disappeared above 3 T. It means that the spins of Fe ions at A and B sites are collinear to the external field. The Fe valence states were determined to be ferric with the isomer shift values.

[1] M. Penchal Reddy, G. Balakrishnaiah, W. Madhuri, M. Venkata Ramana, N. Ramamanohar Reddy, K. V. Siva Kumar, V. R. K. Murthy, R. Ramakrishna Reddy, J. Phys. Chem. Sol. **71**, 1373 (2010).

[2] A. Lucas, R. Lebourgeois, F. Mazaleyrat, and E. Laboure, Appl. Phys. Lett. **97**, 182502 (2010).

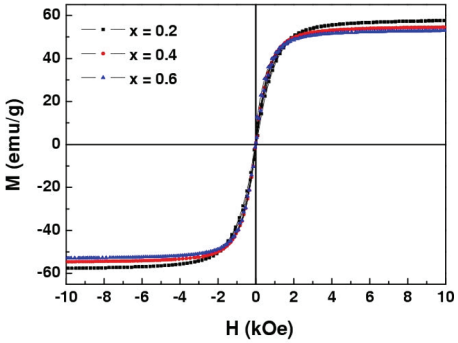

Fig. 1 The magnetic hysteresis loop of $Ni_{0.8-x}Cu_xZn_{0.2}Fe_2O_4$(x = 0.2, 0.4, 0.6) at room temperature.

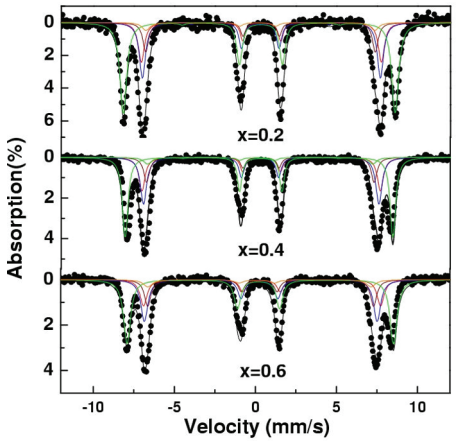

Fig.2 Mössbauer spectra of $Ni_{0.8-x}Cu_xZn_{0.2}Fe_2O_4$(x = 0.2, 0.4, 0.6) at 4.2 K with 5T applied-magnetic field.