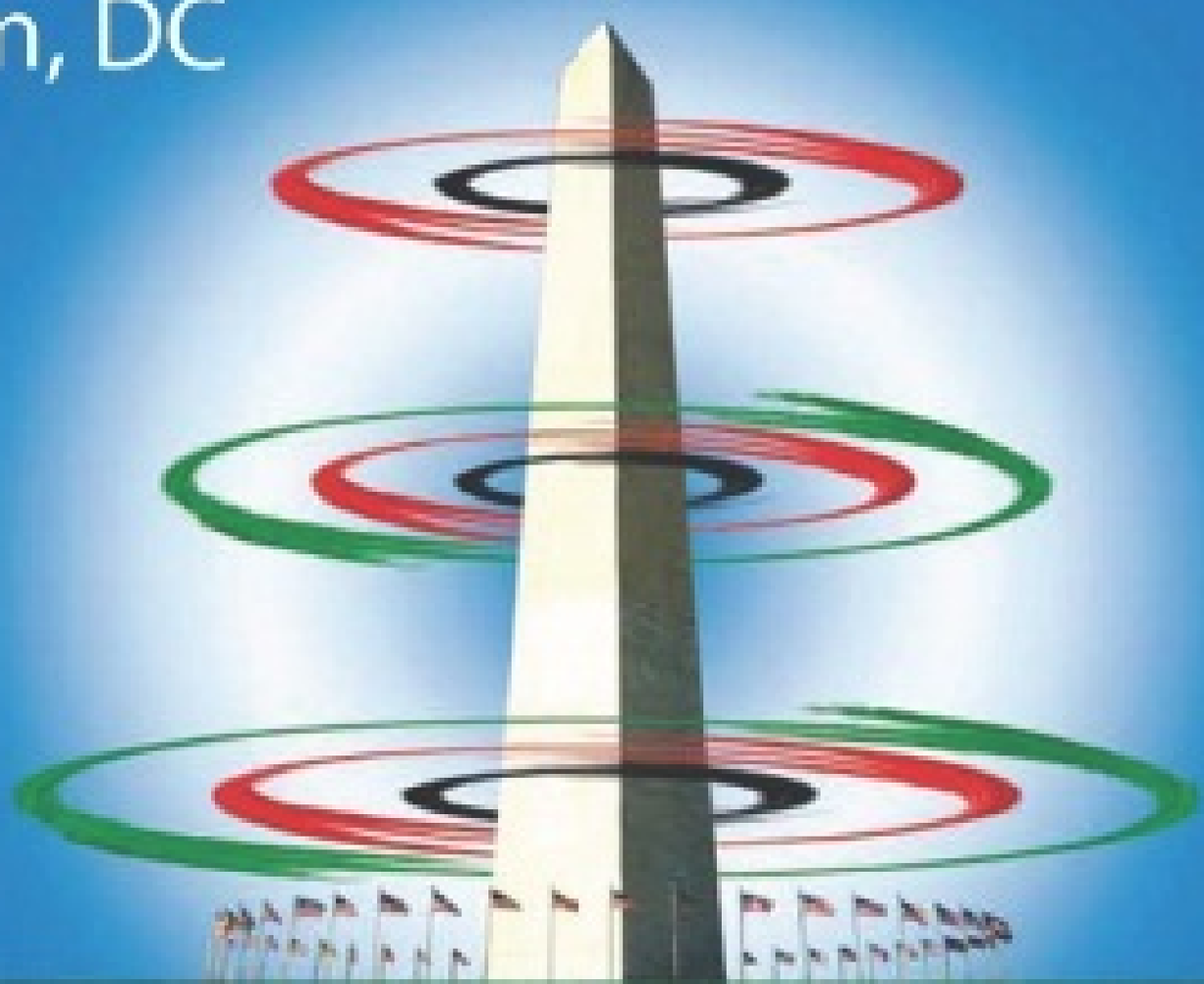
11TH JOINT MMM–INTERMAG CONFERENCE

January 18–22, 2010

Washington, DC

DIGESTS



GQ-07

The geometrical frustration properties of the antiferromagnetic $Ni_{1-x}Fe_xGa_2S_4$ ($0.01 \le x \le 1$).

B. Myoung[1], S. Kim[1], B. Lee[2], C. Kim[1]
1. Physics, Kookmin University, Seoul, Korea, South; 2. Physics, Hankuk University of Foreign Studies, Yongin, Kyungki, Korea, South

1. INTRODUCTION

Recently, it is discovered that chalcogenide $Ni_{1-x}Fe_xGa_2S_4$ (x = 0, 1) were triangular lattice antiferromagnet, which is a form of geometrically frustrated magnet, short-range noncollinear order and incommensurate spin behaviour[1]. Specially, $Ni_{1-x}Fe_xGa_2S_4$ (x = 0, 1) has spin-disordered with strong antiferromagnetic superexchange interactions at low temperature, the spin value for $NiGa_2S_4$ is on low spin state $S = 1$ with only spin-spin correlation, but $FeGa_2S_4$ is on high spin state $S = 2$ with spin-orbital correlation[2-4]. In this research, we have synthesized the magnetic material Fe-doped $NiGa_2S_4$ and studied magnetic properties of spin-orbital interaction, and frustration phenomena by using x-ray diffraction, superconducting quantum interference device (SQUID), and Mössbauer spectroscopy.

2. EXPERIMENT

The polycrystalline samples of $Ni_{1-x}Fe_xGa_2S_4$ ($0.01 \le x \le 1$) were synthesized by annealing at 1000 ^oC in evacuated 10^{-7} torr quartz tubes. The crystal structures of the fabricated samples were investigated by using Philips X'Pert diffractometer in a θ-2θ geometry with Cu $K\alpha$ radiation with wavelength λ = 1.5406 Å. Magnetic susceptibilities were measured with superconducting quantum interference device (SQUID) magnetometer. The Mössbauer spectra were recorded by using a conventional spectrometer of the electromechanical type with a ^{57}Co source in a rhodium matrix.

3. RESULTS AND DISCUSSIONS

The crystal structure of $Ni_{1-x}Fe_xGa_2S_4$ is determined to be a trigonal with space group P-3m1. The lattice constants a_0 and c_0 increase linearly with increasing Fe concentration, since the ionic radius of Fe^{2+} (0.77 Å) is larger than that of Ni^{2+} (0.72 Å), which is consistent with Vegard's law. Magnetic measurements were performed by superconducting quantum interference device (SQUID). Fig. 1 shows the temperature dependence of inverse susceptibility χ^{-1} in field-cooled (FC) magnetization under 5T and dependence of frustration factor(θ_W/T_N), effective moment(μ_B) for $Ni_{1-x}Fe_xGa_2S_4$ ($0.01 \le x \le 1$). The magnetic behaviors of samples show a strong antiferromagnetic character. With increase of Fe, the values of effective moment(μ_B), Néel temperature (T_N), and Curie-Weiss temperature (θ_W) increase linearly, while frustration factor(θ_W/T_N) is about 5 almost constant. It can be explained that spin-orbital correlation of $Ni_{1-x}Fe_xGa_2S_4$ ($0.01 \le x \le 1$) increase with doping of Fe.

The Mössbauer spectra are analyzed from Lorentizans function by determinant for magnetic hyperfine field and electric quadrupole interaction at 4.2 K in Fig. 2. We have observed that the magnetic hyperfine field and electric quadrupole splitting increase with increase of Fe and it can be explained that orbital contribution increases with doping of Fe. Isomer shift (5 mm/s $< \delta <$ 8 mm/s) values show that the charge states are ferrous at all temperature range.

[1] S. Nakatsuji, Y. Nambu, H. Tonomura, O. Sakai, S. Jonas, C. Broholm, H. Tsunetsugu, Y. Qiu, and Y. Maeno, Science **309**,1697 (2005).
[2] S. Nakatsuji, H. Tonomura, K. Onuma, Y. Nambu, O. Sakai, Y. Maeno, R. T. Macaluso, and J. Y. Chan, Phys. Rev. Lett. **99**, 157203 (2007).
[3] Y. Nambu, R. T. Macaluso, T. Higo, K. Ishida, and S. Nakatsuji, Phys. Rev. B **79**, 214108 (2009).
[4] K. Takubo, T. Mizokawa, Y. Nambu, and S. Nakatsuji, Phys. Rev. B **79**, 134422 (2009).

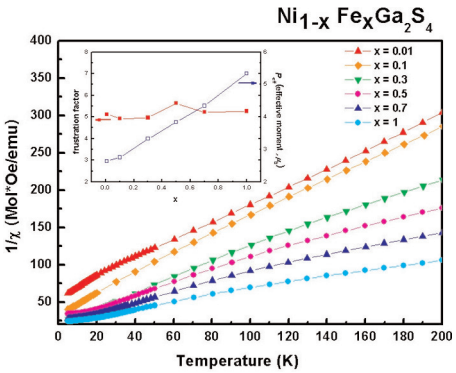


Fig. 1. Temperature dependence of inverse susceptibility χ^{-1}in field-cooled (FC) magnetization under 5T and Fe concentration values dependence of frustration factor(θ_W/T_N), and effective moment(μ_B) for polycrystalline $Ni_{1-x}Fe_xGa_2S_4$ ($0.01 \le x \le 1$).

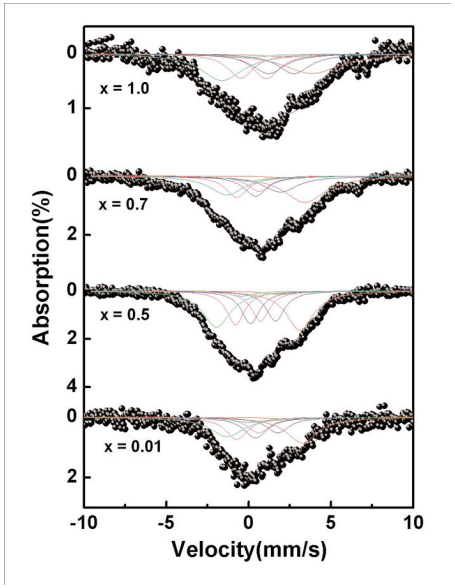


Fig. 2. The Mössbauer spectra for $Ni_{1-x}Fe_xGa_2S_4$ ($0.01 \le x \le 1$) at 4.2 K.