Investigation of site distribution on iron in spinel $FeGa_2O_4$ with Mössbauer spectroscopy

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1. INTRODUCTION

Spinel structures AB_2O_4(A,B=transitionmetal) have attracted much attention, because of the unprecedented magnetic properties such as spin-glass, colossal magnetoresistance(CMR) effect, metal-insulator transition at low temperature.[1,2] Recently, it has been reported that the cubic spinel $FeGa_2O_4$ is antiferromagnet with spin glass behavior with disordered spin, atomic short-range-order, incommensurated spin structure at low temperature. Furthermore, $FeGa_2O_4$ is concurrent with clusters and ferromagnetic spin-ordering below T_f=12K, as superparamagnetic behavior[3,4]. Especially, J.Ghose[5,6] has shown that $FeGa_2O_4$ is purely inverse $[Fe_{0.05}Ga_{0.95}]^A[Fe_{0.95}Ga_{1.05}]^BO_4$, whereas $FeGa_2O_4$ is normal spinel$[Fe]^A[Ga_2]^BO_4$ from Mössbauer measurements[5]. Then, microscopic magnetic properties are as yet unsolved problems with dependent site distribution of iron. In this paper, we have researched magnetic properties of $FeGa_2O_4$, arising from magnetic structure-transition, spin-relocation, and site distribution of iron on dependent temperature.

2. EXPERIMENT PROCEDURES

Synthesis of $FeGa_2O_4$ sample was done by a standard solid-state reaction method in evacuated 10^{-7}torr quartz ampoules. In order to obtain homogeneous materials, it was necessary to grind the mixed powders of Fe (99.99 %), Fe_2O_3(99.995%),andGa_2O_3(99.99%) and press the powder into pellet before annealing process in evacuated quartz ampoules. A single phase of $FeGa_2O_4$ was obtained by annealing at 1000°C with nitrogen gas in evacuated quartz ampoules for 4 days. The crystal structure of sample of $FeGa_2O_4$ was analyzed by using Philips X'Pert diffractometer with Cu *Ka* radiation source. Their magnetic properties were characterized by superconducting quantum interference device (SQUID) magnetometer. The Mössbauer spectra were recorded using a conventional spectrometer of the electromechanical type with a ^{57}Co source in a rhodium matrix. The obtained Mössbauer spectra were analyzed by a least-squares fitting program.

3. EXPERIMENT RESULTS

The X-ray powder diffraction experiment on $FeGa_2O_4$ was performed at room temperature. The diffraction patterns analyzed showed a single-phased material without any impurities. The crystal structure of $FeGa_2O_4$ is determined to be an inverse spinel.

4. DISCUSSION

We conclude that spin-redistribution by distribution of Fe-cations depends on A and B-site with increasing temperature.

5. RESULTS

The crystal structure of $FeGa_2O_4$ is determined to be an inverse spinel, with Fe atoms occupying both tetrahedral(*A*: 43.16 %) and octahedral (*B*: 56.88 %) site from Mössbauer analysis at room temperature. It agrees with the refined XRD analysis result. From temperature dependence of zero-field-cooled (ZFC) and field-cooled (FC) magnetization curves under 100, 400, and 1000 Oe from 4.2 to 300 K, the slopes all of the curves changes depends on temperature. The temperature of change in slope is 25 and 190 K. Then, after each other slops is connected, the meeting temperature is 38 K. It is coincide with the curves electric quadrupole splitting ΔE_Q from Mössbauer analysis. It comes from charge re-distribution due to spin-relocation at 25, 38, and 190 K. Also, each other areas of the Mössbauer spectrum changes with increasing temperature, as area ratio is 53 and 47 % of at 25K, 50, and 50 % at 38 K, and 30 and 70 % at 190 K on A and B site of $FeGa_2O_4$.

6. REFERENCE

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