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Relaxation Effect of $NiCr_{1.8}In_{0.1}Fe_{0.1}O_4$ with Magnetic Anisotropy.

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Introduction : Many researchers were conduct do researches on the chromite materials of spinel structure because of multiferroic effects.[1-3] The $NiCr_{1.9}Fe_{0.1}O_4$ is a ferrimagnet cubic normal spinel at room temperature, in which Ni^{2+} ions occupy the tetrahedral-sites and Cr^{3+} and Fe^{3+} ions occupy the octahedral-sites.[2] Also in the $NiCr_{1.9}Fe_{0.1}O_4$ is a cubic to tetragonal(c/a<1) transition for the Fe concentration x = 0.1 around 230 K.[4]
In this paper, we have studied the impact on magnetic properties of the $NiCr_{1.9}Fe_{0.1}O_4$ as a function of the nonmagnetic Indium(*In*) ion doping by using an x-ray diffraction and magnetization curve measurements and Mössbauer spectroscopy.
Experiments : Polycrystalline samples of the $NiCr_{1.9-x}In_xFe_{0.1}O_4$(x=0.0, 0.1) were prepared by annealing 24 hour in atmosphere at 1200 ^oC with a solid state reaction. The x-ray diffraction patterns of the samples at room temperature were obtained with Cu-*K*α radiation by an x-ray diffractometer (X'PERT). The temperature dependent moment curve was measured by a vibrating sample magnetometer(VSM). The hyperfine magnetic relaxation effects on magnetic anisotropy of samples were evaluated to analysis with temperature dependence of Mössbauer spectra. Mössbauer spectra were measured that a Mössbauer spectrometer of electromechanical type was used in the constant-acceleration mode with a ^{57}Co single-line source in a rhodium(*Rh*) matrix.
Results : The crystalline structure of $NiCr_{1.8}In_{0.1}Fe_{0.1}O_4$ sample at room temperature was determined to be a cubic spinel of *Fd-3m* with a lattice constant a_0 = 8.342 Å at 295 K by Rietveld refinement, while the Bragg R_B and R_F factors were 3.17 and 2.47 % (Figure 1). Figure 2 shows the temperature dependence of the zero field cooled(ZFC) and field coold(FC) magnetization curves for the $NiCr_{1.9-x}In_xFe_{0.1}O_4$(x=0.0, 0.1) under external field of 100 Oe. The magnetic Néel temperature(T_N) is determined by comparing the $d\sigma/dT$ curve of the ZFC measurements with the Mössbauer spectra analysis. As the $NiCr_{1.8}In_{0.1}Fe_{0.1}O_4$, the T_N is determined to be 130 K. Figure 3 shows Mössbauer spectra of $NiCr_{1.8}In_{0.1}Fe_{0.1}O_4$ at various temperature ranges. The Mössbauer spectra show two magnetic phases with the two different magnetic spin direction sites of the Cr^{3+} ion state.[1,5] Mössbauer absorption lines are sharp below 77 K and become broader with increasing temperature. The asymmetric intensities are different from those of the powder pattern 3:2:1. In order to explain the Mössbauer line broadering and 1,6 and 3,4 line-width difference due to the magnetic anisotropic relaxation effect, we use the Blume-Tjon[6] expression. It is noted that the relaxation effect increases rapidly as the temperature approaches the Néel temperature, 130 K.

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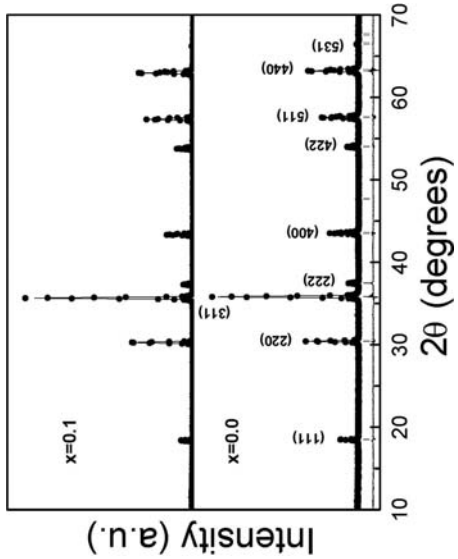

Fig. 1. The x-ray diffraction patterns of $NiCr_{1.9-x}In_xFe_{0.1}O_4$ at room temperature.

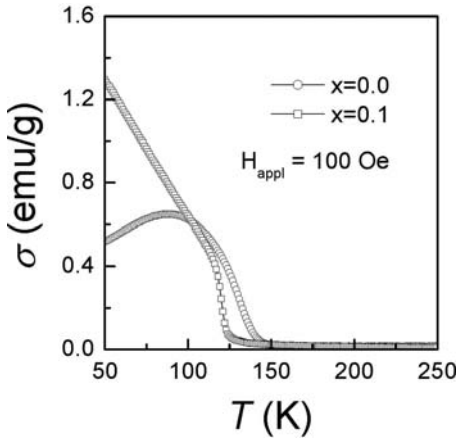

Fig. 2. The temperature dependence of zero field cooled curves $NiCr_{1.9-x}In_xFe_{0.1}O_4$.

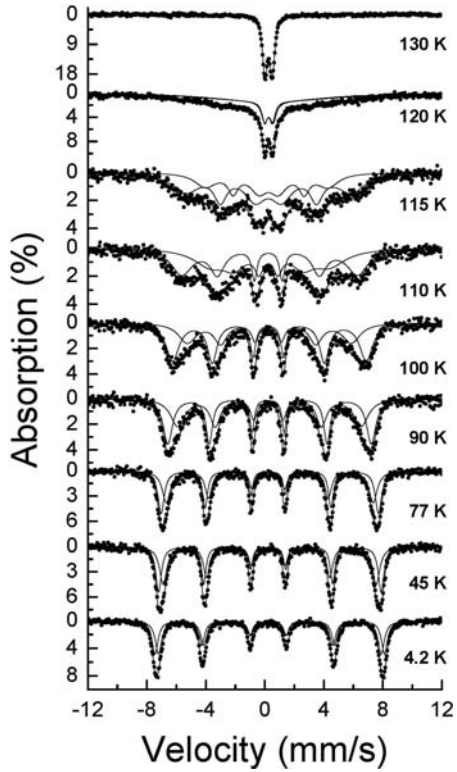

Fig. 3. The Mössbauer spectra of $NiCr_{1.9}In_{0.1}Fe_{0.1}O_4$ at various temperature ranges.