C-7

Exchange Interaction in iron containing garnet

Kookmin University Y. R. Uhm, S. J. Kim, and C. S. Kim

1. Introduction

Rare earth iron garnet and in particular the yttrium iron garnet(YIG) have been extensively studied [1] due to their interesting magnetic properties. In YIG($Y_3Fe_5O_{12}$), both octahedral and tetrahedral sites are occupied by Fe^{3+} ions. The strongest magnetic interaction are the interlattice exchange interactions between the Fe^{3+} ions in the a and d sublattices [2], although the intrasublattice exchange interaction (a-a and d-d) can also be important. Superexchange interaction in Mössbauer spectroscopy is a powerful method by which iron-containing garnets can be studied. The chromium in compounds of the $Y_3Fe_{5-x}Cr_xO_{12}$ (x=0.0,0.25,0.5, and 1.0) distributed at octahedral site. The Mössbauer spectra can be analyses 3 or 4 sets of six Lorentzians with increasing an amount of Cr^{3+} compounds in this system. It results from the distribution($_4C_n$) of Fe^{3+} and Cr^{3+} at octahedral site.

2. Experimental

Compounds of composition $Y_3Fe_{5-x}Cr_xO_{12}$ (x = 0.0, 0.25, 0.5 and 1.0) were prepared by a sol-gel method. Weighed amounts of $Y(NO_3)_3 \cdot 5H_2O$, $Cr(NO_3)_3 \cdot 5H_2O$ and $Fe(NO_3)_3 \cdot 9H_2O$ were first dissolved in ethylene glycol. The solution was refluxed at 80 °C for 12 h to allow gel formation and then dried at 250 °C for 24h. The dried powder was ground and annealed at temperature 900 °C for 6h in air. These compositions of samples fired were identified from an X-ray diffractometer with CuK radiation. Mössbauer spectra were recorded at temperatures ranging from 14 K to room temperature using a helium closed-cycle cryogenerator and a constant acceleration Mössbauer spectrometer with a ^{57}Co in Rh matrix.

3. Results and discussion

It is shown that the grown powders have only a single phase of the garnet structure regardless of the amount of Cr substitution according to the X-ray diffraction patterns. All peaks of XRD patterns can be attributed to cubic structure. The Néel temperature for $Y_3Fe_{4.5}Cr_{0.5}Fe_5O_{12}$ is lower than those observed $Y_3Fe_5O_{12}$. Figure 1 displays the random distribution fitting for Mössbauer spectra measured at 293 K for $Y_3Fe_{5-x}Cr_xFe_5O_{12}$(x= 0.0, 0.25, 0.5, and 1.0) We have fitted the spectra to a model based on a random distribution of Fe or Cr ions. The Cr ion prefers to occupy in octahedral(a-site). Each octahedral Fe3+ is linked through oxygen to six tetrahedral coordinated Fe^{3+} such that all the octahedral sites have identical environments. The Mössbauer spectra can be analyses 3 sets or 4 sets of six Lorentzians with increasing an amount of Cr^{3+}. It results from the distribution($_4C_n$) of Fe^{3+} and Cr^{3+} at octahedral site. The ratios of areas, a, d1, d2, d3, in $Y_3Fe_{4.5}Cr_{0.5}O_{12}$ are 0.33, 0.22, 0.28, 0.14, respectively. The exchange parameters for

$Y_3Fe_{4.5}Cr_{0.5}O_{12}$ were J_{ad} = -52.22 k_B, J_{aa} = -27.85 k_B and J_{dd} = -39.16 k_B, and its value of parameters become larger, as an amounts of Cr decreases in garnet. Figure 2 display Reduced magnetic hyperfine fields $H_a(T)$ / $H_a(0)$ for 16(a) and $H_d(T)$ / $H_d(0)$ for 24(d) in $Y_3Fe_{4.5}Cr_{0.5}O_{12}$ as a function of temperature T/T_N.

Reference

[1] C. S. Kim, Y. R. Uhm, S. B. Kim and J. G. Lee, J. Magn. Magn. Mater., **215-216**,551(2000).

[2] Y. R. Uhm, C. S. Kim, J. G. Lee and K. H. Jeong (to be published)

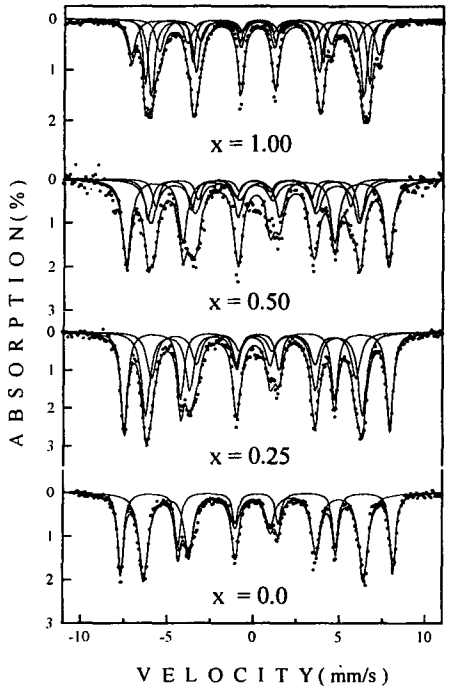

Fig. 1. Temperature dependence of Mössbauer spectra for $Y_3Fe_{5-x}Cr_xO_{12}$(x = 0.0, 0.25, 0.5, and 1.0).

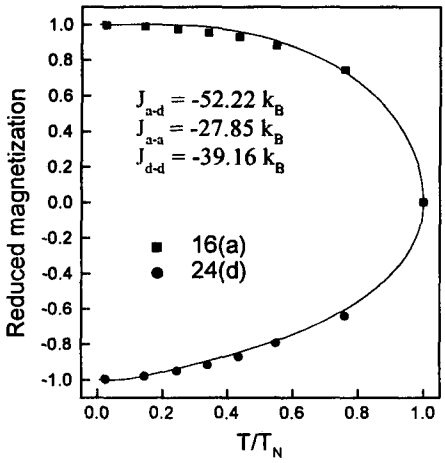

Fig. 2. Reduced magnetic hyperfine fields for 16(a) and 24(d) in $Y_3Fe_{4.5}Cr_{0.5}O_{12}$ as a function of temperature T/T_N. The solid lines represents the σ_a and σ_d .