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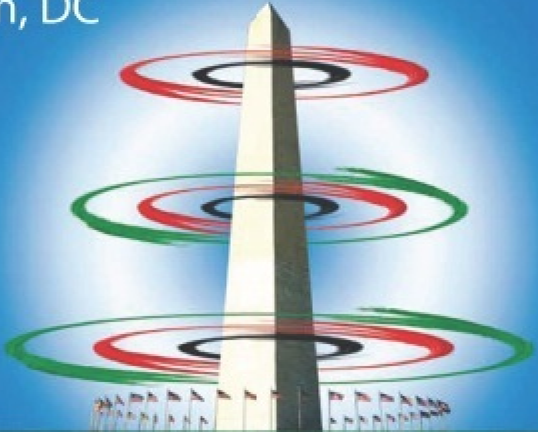
DIGESTS



BV-06

Magnetic properties of the ferrimagnetic $FeCr_{2-x}M_xS_4$ (M = In, Al).

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1. INTRODUCTION

Recently, the Cr-based chalcogenide spinel materials were reported on colossal to magnetoresistance in Cu doped $FeCr_2S_4$ [1], orbital glass state in $FeCr_2S_4$[2], spin-driven phonon splitting in bondfrustrated $ZnCr_2S_4$[3], and coexistence of ferromagnetism and ferroelectricity in $CdCr_2S_4$[4], and $HgCr_2S_4$[5]. Also, Cr-based chalcogenide spinel materials substituted with various diamagnetic ions have been reported by many researchers.

In this study, we have investigated the crystallographic and magnetic properties of $FeCr_2S_4$ substituted with diamagnetic Al^{3+} and In^{3+} ions.

2. EXPERIMENTAL

The polycrystalline $FeCr_{2-x}M_xS_4$ (M = Al, In ; x = 0.1, 0.3) samples were prepared by the solid-state reaction method. High purity powders of Fe (99.99%), Cr (99.99%), Al (99.99%), and S (99.95%) powders were mixed and sealed in a quartz amples. The samples were annealed at 1000 °C for 72 h and slowly cooled down to room temperature (RT) at a rate of 0.2 °C/min. To reach good homogeneity, the synthesis was repeated several times with subsequent regrinding, pressing, and annealing. The crystal structure of the samples was examined by XRD using Cu$K\alpha$ radiation with a wavelength λ = 1.5406 Å. The magnetization measurements were carried out using VSM. The Mössbauer spectra were recorded by keeping the fixed absorber and moving the source by using a conventional spectrometer of the electromechanical type with ^{57}Co source in a Rh matrix.

3. RESULTS AND DISCUSSION

The crystal structure and phase purity of $FeCr_{2-x}M_xS_4$ (M = Al, In ; x = 0.1, 0.3) were examined by XRD measurements, which can be successfully fitted by Rietveld refinement method. The crystal structure is determined to be a cubic spinel with a space group *Fd3-m*. The lattice constants of $FeCr_{2-x}Al_xS_4$ (x = 0.1, 0.3) are found to be a_0 = 9.998, 10.004 Å, respectively, and that of $FeCr_{2-x}In_xS_4$ (x = 0.1, 0.3) are found to be a_0 = 10.029, 10.092 Å, respectively.

The lattice constants of the samples at room temperature are shown in Fig. 1. The lattice constants (a_0) of the samples were linearly increased with Al and In concentration. On the other hand, the increasing ratio of a_0 for In doped samples was larger than that of Al doped samples.

Fig. 2 shows the temperature dependence of magnetization for the samples with the external field of 100 Oe. The Néel temperature (T_N) of the samples was determined to be 163 K and 143 K for $FeCr_{2-x}Al_xS_4$ (x = 0.1, 0.3), and 173 K and 160 K for $FeCr_{2-x}In_xS_4$ (x = 0.1, 0.3), respectively. T_N of the samples was linearly decreased with Al and In concentration.

Finally, it is found that the magnetic hyperfine field (H_{hf}) at 77 K of $FeCr_{2-x}M_xS_4$ (M = Al, In ; x = 0.1) is 203 kOe, 210 kOe respectively. H_{hf} for In doped samples was larger than that of Al doped samples. Also, the electric quadrupole splitting (ΔE_Q) and isomer shift (δ) are found to be 0.76 and 0.21 mm/s and 0.61 and 0.60 mm/s, respectively.

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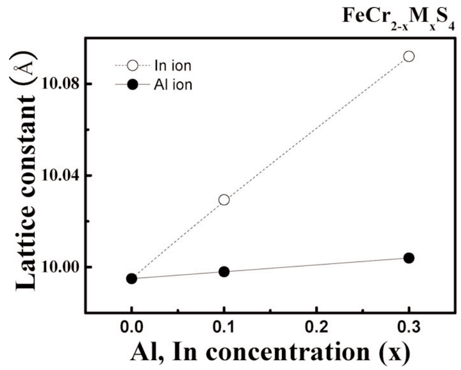

Fig. 1. Lattice constant of the $FeCr_{2-x}M_xS_4$ (M = Al, In ; x=0.1, 0.3) at RT

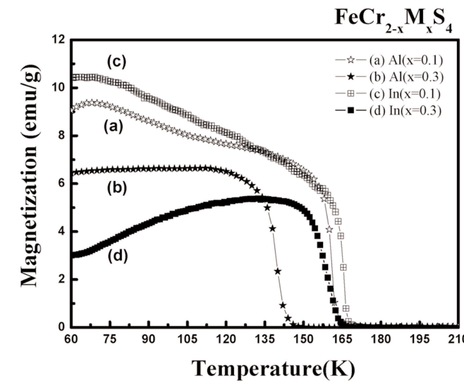

Fig. 2. The temperature dependent magnetization curves for the $FeCr_{2-x}M_xS_4$ with the external field of 100 Oe ZFC (M : Al (x = (a) 0.1, (b) 0.3), In (x = (c) 0.1, (d) 0.3)).