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TEMPERATURE DEPENDENT MÖSSBAUER AND NEUTRON DIFFRACTION STUDIES OF $Cu_xFe_{1-x}Cr_2S_4$ COMPOUNDS

Bae Soon Son[1], Sam Jin Kim[1], In-Bo Shim[1], Bo Wha Lee[2], and Chul Sung Kim[1]
[1]*Dept. of Physics, Kookmin University, Seoul 136-702, Korea*
[2]*Dept. of Physics, Hankuk University of Foreign Studies, Yongin, Kyungki, 449-791, Korea*

The cation distribution and magnetic structure of the $Cu_xFe_{1-x}Cr_2S$ (x=0.0, 0.1, 0.3, and 0.5) has been studied by x-ray and neutron diffraction, vibrating sample magnetometer (VSM), and Mössbauer spectroscopy. The Mössbauer spectra analysis determined the charge state of Fe to be ferrous (Fe^{2+}) for the x=0.0, and 0.1; ferric (Fe^{3+}) for the x=0.5; mixed state (Fe^{2+}, Fe^{3+}) for x=0.3. Moreover from the area Mössbauer absorption ratio, we deduced cation distribution. This result agrees with x-ray diffraction refinement, too. Figure 1 shows the Mössbauer spectra of the samples $Cu_xFe_{1-x}Cr_2S_4$ (x=0.0, 0.1, 0.3, and 0.5) at 13 K. The Mössbauer spectra of the sample x=0.1 show asymmetric line broadening. Considering that Cu^{2+} are Jahn-Teller ions, the distortioned line shape is interpreted well. However, a symmetrical six line pattern is shown for the sample x=0.5. We determined the charge state of Cu to be divalent for the x=0.1 and mono-valance for the x=0.5.

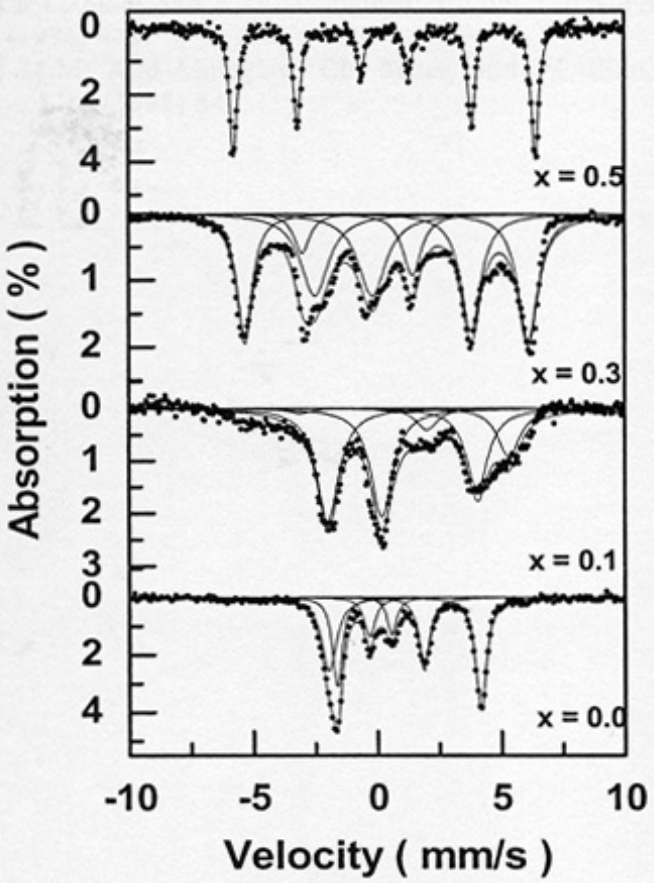

Figure 1. The Mössbauer spectra of $Cu_xFe_{1-x}Cr_2S_4$ at 13 K, (a) x=0.0, (b) x=0.1 (c) x=0.3, and (d) x=0.5.

The magnetic structure for the samples was determined to be ferrimagnetic structure, in which the spin state of Fe, Cr ion are aligned antiparallel by temperature dependent neutron diffraction patterns. Some of the representative diffraction patterns for $Cu_xFe_{1-x}Cr_2S_4$ (x=0.1, 0.3, and 0.5) are presented in Figure 2. The neutron diffraction on $Cu_xFe_{1-x}Cr_2S$ (x=0.1, 0.3, and 0.5) above 10 K exhibited that the magnetic peaks were overlapped on the nucleus peak. The magnetic peak diminished with increasing temperature, disappeared ultimately at Néel temperature. According to the VSM results, magnetic moment and Néel temperature increased with increasing Cu substitution. It is evident that spin ordering of Fe ion and Cr ion are aligned antiparallel. These results agree with neutron diffraction results.

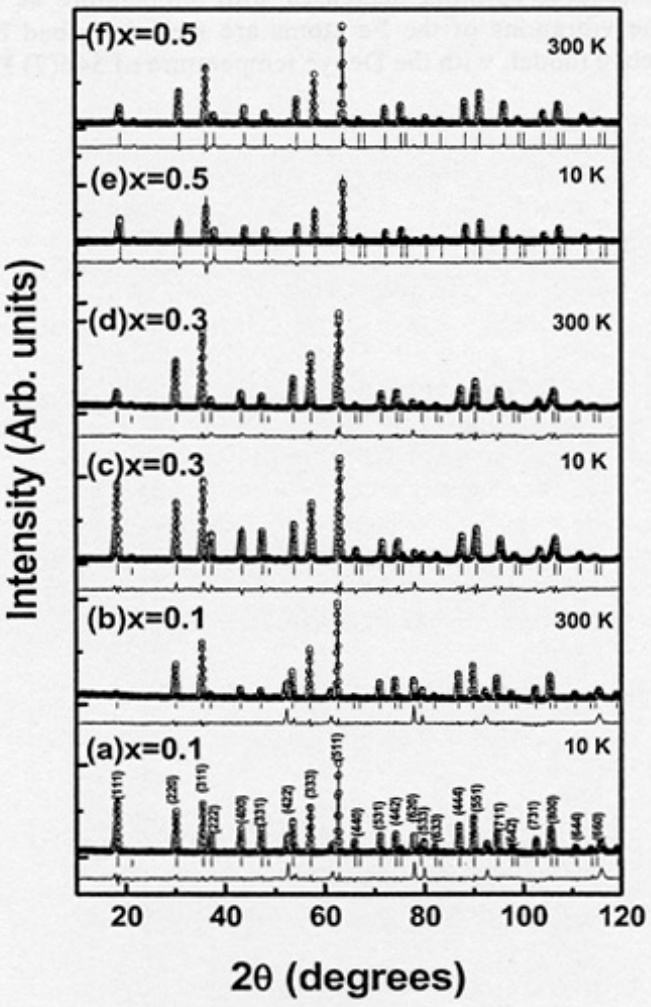

Figure 2. Neutron diffraction patterns of $Cu_xFe_{1-x}Cr_2S_4$ compounds, (a) at 10 K, (b) at 300 K, for the sample x=0.1; (c) at 10 K, (d) at 300 K, for the sample x=0.3; (e) at 10 K, (f) at 300 K, for the sample x=0.5.