Crystallographic and magnetic properties of $Co_xFe_{1-x}Cr_2S_4$

Chul Sung Kim, Min Yong Ha, and Heung Moon Ko
Department of Physics, Kookmin University, Seoul 136-702, Korea

Young Jei Oh
Division of Ceramics, Korea Institute of Science and Technology, Seoul 130-650, Korea

Heung Soo Lee
Microwave Group, Pohang Accelerator Laboratory, Pohang 790-600, Korea

Sang Youl Lee[a] and Jung Chul Sur
Department of Physics, Wonkwang University, Iri 570-749, Korea

Jae Yun Park
Department of Materials Science and Engineering, University of Incheon, Incheon 402-749, Korea

The mixed series $Co_xFe_{1-x}Cr_2S_4$ has been studied by x-ray, Mössbauer spectroscopy, and superconducting quantum-interference device (SQUID) magnetometry. The crystal structure is found to be a cubic spinel, and the lattice constant a_0 decreases linearly with increasing cobalt concentration. Mössbauer spectra of $Co_xFe_{1-x}Cr_2S_4$ have been taken at various temperatures ranging from 4.2 to 300 K. The iron ions are ferrous and occupy the tetrahedral sites. The Curie temperature increases linearly with cobalt concentration, suggesting that the superexchange interaction for the Co-S-Cr link is stronger than that for the Fe-S-Cr link. Magnetic hyperfine and quadrupole interactions in $Co_{0.9}Fe_{0.1}Cr_2S_4$ at 4.2 K have been studied, yielding the following results: $H_{hf}=80.8$ kOe, $\frac{1}{2}e^2qQ(1+\frac{1}{3}\eta^2)^{1/2}=2.65$ mm/s, $\theta=15°$, $\phi=75°$, and $\eta=1.0$. It is notable that, as the temperature decreases below the Curie temperature, quadrupole splitting increases with decreasing temperature, suggesting the presence of an electric field gradient and accompanying relaxation effects. Magnetic susceptibility measurements by SQUID magnetometry show that superexchange interactions between Fe^{2+} ions are ferrimagnetic.