JOURNAL OF APPLIED PHYSICS **117**, 17B741 (2015)

Spin reorientation in multiferroic spinel $Co_{0.5}Fe_{0.5}Cr_2O_4$ with Mössbauer spectroscopy

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(Presented 5 November 2014; received 22 September 2014; accepted 12 December 2014; published online 27 April 2015)

We studied the magnetic properties of multiferroic spinel $Co_{0.5}Fe_{0.5}Cr_2O_4$, especially focusing on the spin-ordering, spin-reorientation, and charge re-distribution effects. From the Rietveld refinement analysis, the crystal structure was identified to be a normal cubic spinel of *Fd-3m*. Based on the temperature-dependent measurements of the magnetization and magnetic hyperfine field (H_{hf}), Curie temperature (T_C) of $Co_{0.5}Fe_{0.5}Cr_2O_4$ was determined to be around 86 K where $H_{hf} \cong 0$. From the change of slope in the M-T curve, the conical-spiral magnetic ordering temperature was determined to be 20 K, which coincides with H_{hf} measurement. Also, we have observed the decrease in the slope of the electric quadrupole splitting (ΔE_Q) curve above 20 K, suggesting that the change in ΔE_Q around T_S is originated from charge redistribution due to the spin-relocation associated with the distortion of each tetrahedral site around Fe^{2+} ion above T_S. This indicates that $Co_{0.5}Fe_{0.5}Cr_2O_4$ has the noncollinear conical-spiral spin ordering with incommensurate spin structure below T_S, while above T_S, it has ferrimagnetic spin ordering with commensuration in the collinear state. In addition, the Jahn-teller distortion temperature is measured to be around 155 K, since both ΔE_Q and Δ_1 of $^5T_{2g}$ band decrease rapidly with increasing temperature and disappear around 155 K.
[http://dx.doi.org/10.1063/1.4918968]