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Microscopic evidence of magnetic and structure phase transition in multiferroic spinel FeV_2O_4

Bo Ra Myoung, Sam Jin Kim, Jung Tae Lim, Taejoon Kouh, and Chul Sung Kim[a]
Department of Physics, Kookmin University, Seoul 02707, South Korea

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We report the microscopic evidence for magnetic and structural phase transitions in multiferroic spinel FeV_2O_4 from the hyperfine magnetic interaction. FeV_2O_4 sample shows three different crystal structures with the phase transitions from tetragonal to orthorhombic structure around 70 K, from orthorhombic to tetragonal structure around 109 K, and from tetragonal to cubic structure around 140 K. Mössbauer spectra of FeV_2O_4, obtained at various temperatures, were analyzed with severely distorted 8-line below $T_{C,}$ and doublet at T_C. Also, the Mössbauer spectra change from doublet to singlet around $T_{JT} \cong 140$ K due to the reduction of Jahn-Teller effect. The value of electric quadrupole splitting (ΔE_Q) is 3.05 mm/s at 4.2 K, indicating the noncollinear spin structure with strong polarization from the gap energy of $^5T_{2g}$ band, $\Delta_1 \cong 0$. Whereas, there is collinear spin structure between $T_S \cong 70$ K $< T < T_C \cong 109$ K, since Δ_1 in this temperature range increases from the value when $T < T_S$ due to the non-degenerate energy state with commensuration in the collinear state. Also, we have found that large polar angle θ for $T < T_S$ suggests the spin of the Fe^{2+} cations aligns along c-axis with the distortion in the a-b plane, while the small azimuthal angle θ suggest the direction of the spin is within ab-plane for $T_S < T < T_C$. [http://dx.doi.org/10.1063/1.4977549]