Improved magneto-dielectric properties in Co substituted Cr ferrites for miniaturized antenna applications

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Abstract

The composition $Cr(Fe_{1-x}Co_x)_2O_4$ with x= 0.0, 0.1, 0.5, and 0.9 has been synthesized using the solid-state reaction method followed by the double sintering technique of pre-sintering at 800 ℃ and sintering at 1332℃. The structure and cationic distribution in the studied samples obtained by the Rietveld refinement of X-ray diffraction (XRD) patterns confirm a mixed spinel cubic structure of Fd3m space group, with a reduction in impurity phase (α-Fe_2O_3) as Co^{2+} substitution increases. In addition, the scanning electron microscopy (SEM) of these samples indicates a decrease in grain size and porosities with higher Co content. The magnetic hysteresis measurement by a vibrating sample magnetometer (VSM) reveals that Co^{2+} substitution at Fe^{3+} enhances the magnetic properties, with maximum saturation magnetization (M_s) of ~4.03×10^{-2} μ_B/F. U and coercivity (H_c) of ~102.1 Oe observed for x = 0.5. In addition, the frequency-dependent permeability (μ) improves with Co doping in Cr ferrite, and dielectric studies exhibit reduced loss tangent ($tan\delta$) and enhanced dielectric quality factor (Q_ε). Finally, the matching impedance becomes stable across a broad frequency range (3 kHz to 7 MHz) with $Z/\eta_0 \approx 0.75$, resulting in the Co-substituted Cr ferrites as promising materials for miniaturized antenna applications including superior magneto-dielectric performance and eco-friendly composition.

Keywords: Cr ferrite, Rietveld refinement, SEM, Hysteresis loop, Matching impedance