Finding the best frequency dependent performance of 3d transition metals (Co, Ni, and Mn) substituted nano magnetite for miniaturizing device applications

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Abstract

Ferrite samples with enhanced magneto-dielectric properties are more essential in electromagnetic applications. Therefore, a parent composition of Fe_3O_4 has been modified by substituting 3d transition metal elements (Co, Ni, Mn) at a single Fe atom using the co-precipitation synthesis method. The structural properties of the synthesized Fe_3O_4, $NiFe_2O_4$, $CoFe_2O_4$, and $MnFe_2O_4$ samples have been evaluated from the X-ray diffraction patterns. The surface morphology and microstructures of the studied samples were studied by field emission scanning electron microscopy and the average grain size of all the studied samples varied from 60.11 to 106.03 nm. The magneto-dielectric properties were analyzed by frequency dependent permeability (μ) and permittivity (ε) measurements for the range of 100 Hz to 100 MHz. The conduction process for the synthesized ferrites has been noticed from the ac conductivity (σ_{ac}). The localized relaxation mechanism for the studied ferrites has been observed from the variation of imaginary portion of the electric modulus (M'') and the impedance (Z''). Moreover, the mismatch (Z/η_o) between the impedance of the antenna substrates (Z) made of the studied samples and air (η_o) has been evaluated from the permeability and permittivity. Finally, $NiFe_2O_4$ has been derived as a suitable ferrite for miniaturizing devices over a frequency range of 10 kHz-6.5 MHz.

Keywords: Ferrite, 3d transition metals, X-ray diffraction, Permeability, Permittivity, Electric modulus