

Improved magnetic and dielectric quality factors with low losses in rare earth (Eu) substituted Co-Ni-Zn ferrites for high frequency devices

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Abstract

$\text{Co}_{0.2}\text{Ni}_{0.5}\text{Zn}_{0.3}\text{Eu}_x\text{Fe}_{2-x}\text{O}_4$ (CNZEFO) composites were synthesized by the conventional double sintering technique, where $x = 0.00, 0.02, 0.04, \text{ and } 0.08$. Rietveld refined x-ray diffraction indicates the spinel cubic structure (Fd-3m space group) of the samples. The refined XRD pattern also mentioned the Fe_2O_3 secondary peak for $x = 0.04$ and 0.08 samples. The structural lattice constant was initially increased, but after that it decreased with the Eu concentration. The bulk density of the samples was always lower than the x-ray density, where the densities were increased with the enhancement of Eu concentration. FTIR analysis confirmed the metal-oxygen bonds in ferrite with spinel cubic structure. FESEM micrographs provide the average grain size of the samples, which varies between 105.1 nm and 169.9 nm. EDX analysis was used to carry out the compositional verification and confirm that the elements were present in the required ratios. Magnetic hysteresis loop measurements were studied at room temperature, where the magnetization demonstrates the decline with the substitution of Eu ions. The addition of Eu concentration also changed other fundamental properties of the ferrites, such as coercivity (H_C), retentivity (M_r), anisotropy constant (K), and magnetic moment (n_B). The permeability measurements show that the real permeability of the samples was decreasing at lower frequency regions further they became high at higher frequency regions. The magnetic loss tangent ($\tan\delta_M$) and dielectric loss tangent ($\tan\delta_D$) were reduced with the addition of Eu concentration, where the Eu-doped samples show higher dielectric and magnetic quality factors than the pure sample. The enhancement of resistivity and impedance was also noticed for the addition of Eu content in the $\text{Co}_{0.3}\text{Ni}_{0.2}\text{Zn}_{0.5}\text{Fe}_2\text{O}_4$ sample. These europium-doped cobalt-nickel-zinc ferrites may be strong candidates for potential high-frequency applications.

Keywords: CNZEFO, Spinel cubic, FESEM, Quality factor, Impedance.