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Structure and Mössbauer studies of Cu-doped Ni–Zn ferrite

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Abstract

$Ni_{0.65}Zn_{0.35}Cu_xFe_{2-x}O_4$ ($x = 0.0$–0.3) was studied with X-ray diffraction, Mössbauer spectroscopy and vibrating sample magnetometer (VSM). The crystal structure was found to be a cubic spinel, and the lattice constants increased linearly with increasing quantity of Cu ions with the lattice constant $a_0 = 8.384 \pm 0.005$ Å at $x = 0.0$. Mössbauer spectra of $Ni_{0.65}Zn_{0.35}Cu_xFe_{2-x}O_4$ ($x = 0.0$–0.3) were taken at various temperatures ranging from 12 to 725 K. As the temperature increased toward T_N, a systematic line broadening effect in the Mössbauer spectra was observed and was interpreted as originating from different temperature dependencies of the magnetic hyperfine fields at various iron sites. The isomer shifts indicated that the iron ions were ferric at the tetrahedral [A] and the octahedral sites [B]. The quadrupole shifts showed that the orientation of the magnetic hyperfine field with respect to the principal axes of the electric field gradient was random. The magnetic hyperfine field values indicated that A sites had more A–O–B superexchange interactions than the B sites. The Néel temperature decreased with increasing quantity of Cu ions with $T_N = 725 \pm 2$ K at $x = 0.0$. Also, the Debye temperatures of the A and B sites of $Ni_{0.65}Zn_{0.35}Cu_{0.1}Fe_{1.9}O_4$ were found to be $\Theta_A = 228 \pm 5$ K and $\Theta_B = 328 \pm 5$ K. The VSM data showed that the magnetic moment decreased with increasing quantity of Cu ions with magnetic moment and coercivity values of $M_s = 66$ emu/g and $H_c = 36$ Oe at $x = 0.3$.

Keywords: Ferrites; Mössbauer spectroscopy; Magnetic hyperfine field; VSM