The Effect of Copper Ion Substitution on the Magnetic Microstructure and Magnetic Characteristics of Nickel Ferrite

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Ferrites with a spinel structure attract considerable attention from researchers due to their good magnetic properties and the possibility to change their characteristics in a wide range, using different methods and conditions of synthesis and selective replacement of them with magnetic or non-magnetic elements [1]. Among the spinel ferrites, nickel ($NiFe_2O_4$) and copper ($CuFe_2O_4$) ferrites are particularly interesting due to their high magnetocrystalline anisotropy, high saturation magnetization, and electrical resistance [2]. In the inverted spinel structure, Ni and Cu ions occupy the octahedral (B) sublattice, however, when nickel ferrite is replaced by copper ions, the latter can be localized both in octa- and tetra-sublattices, displacing iron ions from there. Thus, preconditions are created for changing the magnetic parameters with the corresponding variation in the concentration of the substituting element and the synthesis conditions.

Nanosized copper-substituted nickel ferrite was synthesized by a single-step, energy-saving, and environmentally friendly sol-gel autocombustion method. To determine the effect of substitution on the structure and magnetic characteristics, the obtained samples were studied by several methods, including X-ray diffraction (XRD), vibrating-sample magnetometry (VSM), and ^{57}Fe Mössbauer spectroscopy.

The results of the research showed that with an increase of copper ions in the content. Also, we observed a non-monotonically decrease in saturation magnetization values and other parameters (remanent magnetization, coercive force, and magnetocrystalline anisotropy coefficient). These changes have related to the presence of copper ions in both the octa- and tetra-sublattices. The Mössbauer spectra show that the influence of the dopant is manifested in the fact that a paramagnetic doublet appears and grows, which is a result of the effect of non-magnetic ions near Fe nuclei.

References:

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