Modification of Structure and Magnetic Characteristics of Nickel Ferrites by Ruthenium Substitution

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Abstract. Spinel nickel ferrites partly substituted by ruthenium ions with base chemical composition $Ni_{1+x}Ru_xFe_{2-2x}O_4$, where x = 0.000, 0.025, 0.050, 0.075 and 0.100 i./f.u. were synthetized and characterized from the point of view of the relationship between the synthesis route and the resulting structural and magnetic properties. The ferrite samples were synthesized by means of double-sintering ceramic process based on solid-state reaction. Two sintering temperatures (1200 °C as well as 1350 °C) were used successively during 6 hours with temperature rise 4 °C/1 minute before each sintering. This way, ferrite powder as well as ring-shaped specimens were produced. The microstructure and morphology were monitored by SEM; well-developed crystalline structure of all prepared ferrite samples was confirmed. The qualitative and quantitative analysis were accomplished by EDX. EDX analysis showed that the real amount of Ru grows with increasing x together with the decrease of Fe content; thus, the successful substitution of Fe by Ru ions in the ferrite spinel structure can be assumed. The effect of Ru substitution on selected magnetic properties, such as the Curie temperature, coercive field, remanent magnetic flux density, hysteresis loop area, amplitude and initial permeability, etc., was studied. Important low-frequency magnetic parameters were found from the magnetic characteristics, measured at precisely defined exciting conditions, i.e., hardware feedback-controlled sinusoidal exciting field waveform. The Curie temperature was evaluated from the temperature dependencies of volume magnetic susceptibility. Presented research outcomes point at quite complex link among the chemical composition, distribution of ionic magnetic dipole moments into tetra- and octahedral spinel sublattice, and the microstructure of prepared materials on one side, and the resulting electromagnetic properties on the other side.

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