Structural, thermodynamic, and magnetic properties of $SrFe_{12}O_{19}$ hexaferrite modified by co substitution of Cu and Gd

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Abstract

A hard magnetic system of $SrFe_{12}O_{19}$ nanomaterial was modified according to the composition of $Sr_{0.95}Gd_{0.05}Fe_{12-x}Cu_xO_{19}$ with x = 0.0, 0.30, and 0.60 using the sol–gel technique. The structures of the samples were evaluated using X-ray diffraction (XRD) along with Rietveld refinement, and an M-type hexaferrite with a hexagonal structure was confirmed with a trace amount of the α-Fe_2O_3 phase. In addition, transmission electron microscopy (TEM) analysis revealed polycrystalline nanoplates in all samples. Furthermore, the bond structures of the octahedral and tetrahedral sites along with the thermodynamic properties of these ferrites were extracted from the FTIR spectra at room temperature. The Debye temperature (θ_D) decreased from 755.9 K to 749.3 K due to the co-substitution of Gd^{3+} at Sr^{2+} and Cu^{2+} at Fe^{3+}. The magnetic hysteresis (M–H) measurements revealed that the coercivity decreased from 5.3 kOe to 1.5 kOe along with the highest magnetization saturation (M_s) of 65.2 emu g^{-1} for the composition $Sr_{0.95}Gd_{0.05}Fe_{11.7}Cu_{0.3}O_{19}$, which is suitable for industrial application. The effect of local crystalline anisotropy in magnetization was explored using the law of approach to saturation (LAS). Finally, thermo-magnetization was recorded in the range from 400 K to 5 K for cooling under zero field and in the presence of a 100 Oe field, and magnetic transitions were tracked due to the introduction of the foreign atoms of Gd and Cu into $SrFe_{12}O_{19}$.

Keywords: Hexaferrite, Co substitution, Debye temperature, magneto-crystalline anisotropy, Thermo-magnetization