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Effects of isovalent substitution on structural and magnetic properties of nanocrystalline $Y_{3-x}Gd_xFe_5O_{12}$ ($0 \leq x \leq 3$) garnets

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ABSTRACT

We fabricated Gd-doped $Y_3Fe_5O_{12}$ (YIG) nanoparticles by a modified sol–gel method. We investigated the effects of isovalent Gd^{3+}-ion substitution on the structural and magnetic properties of $Y_{3-x}Gd_xFe_5O_{12}$ ($0 \leq x \leq 3$) nanoparticles. Isovalent Gd^{3+}-ion substitution for Y^{3+} leads to lattice expansion and change in the Fe(a)–O–Fe(d) bond angle. The X-ray photoemission spectroscopy and Mössbauer measurements revealed a high-spin state of Fe^{3+}. The Mössbauer analysis showed an increase in the $Fe^{3+}_{(d)}/Fe^{3+}_{(a)}$ ratio, indicating a relocation of Y^{3+} ions at the dodecahedral sites and Fe^{3+} ions at the octahedral sites. The magnetic properties could be explained in terms of magnetic-structural evolution with increasing Gd^{3+} content. The field dependence of magnetization indicated a clear decrease of the magnetization while the magnetic anisotropy first decreases and then increases with the increase of Gd^{3+} content. These Gd^{3+}-ion-substituted nanocrystalline garnet ferrites are suitable for use in a variety of magneto-optical applications.