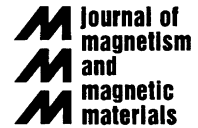




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Mössbauer studies of $Y_3Fe_{4.75}Al_{0.25}O_{12}$

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Abstract

Al^{3+} substituted garnet $Y_3Fe_{4.75}Al_{0.25}O_{12}$ was fabricated by a sol–gel method. Its crystallographic and magnetic properties have been studied by Mössbauer spectroscopy, X-ray diffraction (XRD), thermogravimetry analysis (TGA), differential thermal analysis (DTA), and vibrating sample magnetometer (VSM). The crystal structure is found to be cubic with a lattice constant $a_0 = 12.3612 \pm 0.0005 \text{ \AA}$. Mössbauer spectra of were measured at various absorber temperatures of 20 to 700 K. The Néel temperature T_N is found to be $555 \pm 3 \text{ K}$. As the temperature increased toward T_N , a systematic line broadening effect in the Mössbauer spectra was observed and interpreted to originate from different temperature dependencies of the magnetic hyperfine fields at various iron states. It results from the distribution (${}_6C_n$) of Fe^{3+} and Al^{3+} at tetrahedral site. The isomer shifts indicated that the iron ions were ferric at the octahedral 16a-site and the tetrahedral 24d-sites. The quadrupole splits showed that the orientation of the magnetic hyperfine field with respect to the principal axes of the electric field gradient was random. Mössbauer spectra were analyzed with 3 subspectra of Fe sites (16a₁, 16a₂ and 24d), with the hyperfine field of individual subspectra at 20 K being $H_{hf}(16a_1) = 550$, $H_{hf}(16a_2) = 547$, and $H_{hf}(24d) = 473 \text{ kOe}$, respectively. The average hyperfine field $H_{hf}(T)$ of the $Y_3Fe_{4.75}Al_{0.25}O_{12}$ shows a temperature dependence of

$$[H_{hf}(T) - H_{hf}(0)]/H_{hf}(0) = -0.28(T/T_N)^{3/2} - 0.14(T/T_N)^{5/2}$$

for $T/T_N < 0.7$, indicative of spin-wave excitation. The area fractions of the Fe sites, 16a₁, 16a₂, 24d at 20 K were 25%, 15%, and 60%, respectively. The saturation magnetization M_S was 23 emu/g at room temperature under the applied field of 10 kOe annealed at 1200°C in air atmosphere for 6 h. © 2002 Elsevier Science B.V. All rights reserved.

Keywords: Garnet; Mössbauer; Sol–gel
