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Magnetic Properties of $Nd_{1-x}Bi_xY_2Fe_5O_{12}$ Thin Films and Powder Grown by a Sol-gel Method

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Abstract

$Nd_{1-x}Bi_xY_2Fe_5O_{12}$ (x = 0.0, 0.25, 0.5, 0.75, 1.0) thin films and powder were fabricated by a sol-gel method and their magnetic properties and crystal structures were investigated by using x-ray diffractometor, atomic force microscopy(AFM), scanning electron microscopy(SEM), Rutherford back scattering(RBS), vibrating sample magnetometer(VSM), and Mössbauer spectroscopy. Films with homogeneous garnet phases were obtained from stock solutions spun on SiO_2/Si(100) substrates and fired at 600 ~ 800 °C for 1 hour in air. Films had no any preferred direction. X-ray diffraction patterns of $Nd_{1-x}Bi_xY_2Fe_5O_{12}$ had only peaks of the garnet structure. The microstructure of the films with a square shapes consisted of 200 nm in size and 2 ~ 3 nm in surface roughness. The garnet of $Nd_{1-x}Bi_xY_2Fe_5O_{12}$ had the largest saturation magnetization, 184 emu/cm^3, and the lowest coercivity, 27 Oe. The magnetic properties were strongly dependent on annealing temperatures. The results for magnetic properties indicated that the saturation magnetization was fixed however, the coercivity decreased with increasing Bi concentration. The Mössbauer spectra were taken at various temperatures ranging from 12 to 650 K. The isomer shifts indicated that the valence states of Fe ions for the 16(a) and the 24(d) sites had ferric character. The Curie temperature of $Nd_{1-x}Bi_xY_2Fe_5O_{12}$ decreased with increasing Bi concentration. Spin waves having long wavelengths were excited with increasing an amount of Bi.