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SYNTHESIS AND MÖSSABUER SPECTROSCOPY STUDIES ON FINE-PARTICLE $Nd_{1-x}Bi_xY_2Fe_5O_{12}$

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1. Introduction

Fine-grained rare-earth iron garnet (RIG) is of interest for microwave devices and magneto-optic media because the threshold magnetic field H_c is enhanced for the nonlinear excitation of spinwave modes[1]. Previous studies have shown that YIG powders, which substitute Y-ions with Bi-ions, had a lower coercivity than the pure YIG powder did[2]. Nd-ions in a ferrite powder have high magnetization and can be easily substituted with Y or Bi. A number of wet chemical methods have been developed to prepare fine particle[3] and one of them is a sol-gel pyrolysis method, which is used to fabricate ultra-fine ferrite powders in our laboratory[2]. In this study, $Nd_{1-x}Bi_xY_2Fe_5O_{12}$ powders are grown by a sol-gel method and their magnetic and physical properties are characterized by using X-ray diffraction, a vibrating sample magnetometer(VSM), scanning electron microscopy (SEM) and Mössbauer spectroscopy.

2. Experiment

Polycrystalline $Nd_{1-x}Bi_xY_2Fe_5O_{12}$ powders were prepared by the sol-gel method containing ethylene glycol[4]. Crystalline garnet powders were obtained after heat treatment at 800-1000 °C in an O_2 flow for 8 hours. X-ray diffraction patterns of samples were obtained with a Cu-K_α radiation. Crystal shapes and grain sizes were also examined with a scanning electron microscope and a Mössbauer spectroscope of the electromechanical type was used for determining magnetic phases of garnet powders and the Néel temperatures. The detailed information of the magnetization of garnet powders was obtained by a VSM at room temperature while an external field was applied up to 10 kOe.

3. Results and discussion

X-ray diffraction patterns of the grown powders exhibit the single-phased cubic structure regardless of the amount of Bi substitution. Scanning electron microscopy images of the powders indicate that the powders are composed of grains with the averaged size of 200-300 nm. However, the grain sizes decrease as an amount of Bi in YIG powders increases. Powders heated at and below 800 °C contain a small amount of α-Fe_2O_3. A typical SEM image of the $Nd_{0.75}Bi_{0.25}Y_2Fe_5O_{12}$ powder annealed at 950 °C is shown in Fig. 1. Figure 2 shows Mössbauer absorption spectra measured as a function of the Bi concentration at room temperature. The spectra are composed of two six-line hyperfine pattern 16(a) and 24(d) site, which is a typical pattern for a garnet powder. The Néel temperature slowly decreases from 630 to 600 K as the Bi concentration increases from x=0.0 to x=1.0. This result indicates that the superexchange interaction of Bi-O-Fe linkage weaker than Nd-O-Fe linkage. Debye temperatures of 16(a) and 24(d) decrease as the amount of Bi substitution increase to Nd-YIG. The increasing amount of

Bi yields the larger values of spin-wave constants. Spin waves have long wavelengths and they are excited in the Bi substituted to Nd-YIG. The spin wave constants($B_{3/2}$) of $Nd_{1-x}Bi_xY_2Fe_5O_{12}$ (x=0.25,0.5,0.75,1.0) were 0.17,0.19,0.2,0.21, respectively. The maximum saturation magnetization of the garnet powders is 27(emu/g). Figure 3 shows that the saturation magnetization of powders is independent on an amount of Bi content but the coercivity (H_c) rapidly decreases as the amount of Bi in the garnet powders increases. In this study, we could observe that (Nd-Bi;Y)IG exhibit higher saturation magnetization and hyperfine fields than those of (Bi;Y)IG.

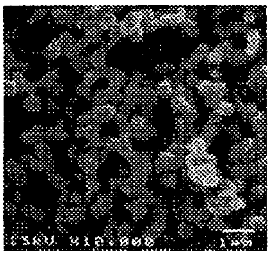

Fig. 1 The scanning electron microscopy image of $Nd_{0.75}Bi_{0.25}Y_2Fe_5O_{12}$.

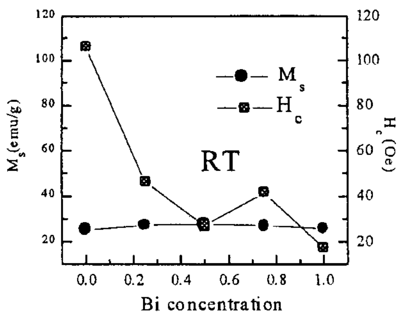

Fig. 3. The saturation magnetization (M_s) and coercivity as function of Bi concentration.

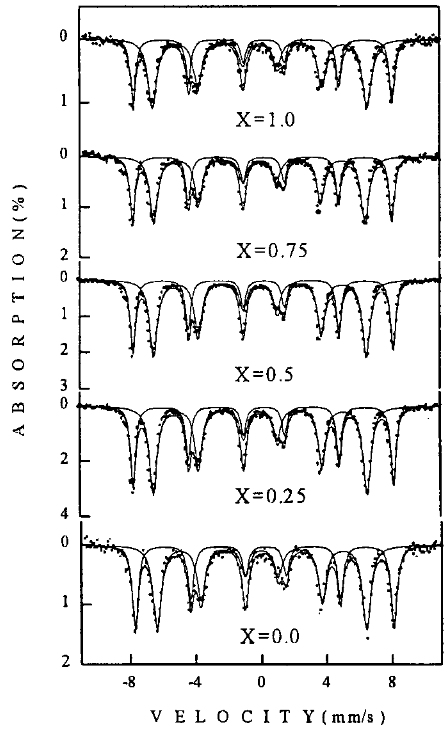

Fig. 2. Mössabuer spectra of powder $Nd_{1-x}Bi_xY_2Fe_5O_{12}$ at room temperature.

4. Refernces

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