Magnetic properties of Bi substituted garnet thin film on GGG (100) and (110) substrate for MO indicator

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Introduction

The Magneto-optical imaging (MOI) of the magnetic flux using Bi substituted magnetic garnet film (we call MO indicator film) is widely used for the characterization of the high T_c superconductors. For the high sensitivity and spatial resolution, the thin film with highly Bi substitution and in-plane magnetic anisotropy are necessary. In the past report, the thin film on (100) substrate was cleared to be more suitable for preparing in-plane magnetic anisotropy than the film on (111) substrate. The magnetic easy axis lies along <111> direction for the case of magnetic garnet. From the point of view of the magnetic crystalline anisotropy, we think that the film on (110) substrate is easier to prepare in-plane magnetic anisotropy because the <111> axis is in-plane. We focused on the comparison of the magnetic anisotropy among the (111), (100) and (100) films prepared on (111), (100) and (100) substrates.

Experimental

For the film preparation, we used liquid phase epitaxy (LPE) technique. This technique is easy to control the film composition and is suitable for the preparation of the films with optically smooth surface. The thin films were grown on $Gd_3Ga_5O_{12}$ (GGG) single crystal substrate. The thickness was determined by Infra-red spectrometer. The lattice constant and mismatch was determined by X-ray diffraction analysis. The compositions of the films were analyzed using an Energy Dispersive X-ray spectrometer (EDX). The magnetization was measured with a vibrating sample magnetometer (VSM). Faraday hysteresis curve was measured at a wavelength of 635 nm.

Results and Discussion

Under the same growth condition such as melt composition and growth temperature, the growth rate of the (110) film case became slow in comparison with the case of (100) and (111) film. Lattice constant of these films was different; (110) film was larger than the others. The EDX analysis shows the different composition ratio of the Bi/Lu ions between (110) film and the other films. It was thought that the reason of lattice constant. The composition ratio of Fe ions of all film were almost the same. The magnetization of the (110) film is larger than that of the other films. The (111) film show the isotropic magnetization, on the other hand, the (100) and the (110) film show the magnetic anisotropy parallel to the film plane. The Faraday hysteresis curve shows that the large Faraday rotation value for the (110) film is in good agreement with larger content of Bi^{3+} ions obtained by EDX analysis. The (100) and (110) film has no magnetic domain structures. This is also the evidence of the magnetic anisotropy parallel to the film plane. For the application of the MO indicator, it can be concluded that the (110) film, as well as the (100) film, is easy to control the magnetic anisotropy parallel to the film plane. In addition, the larger MO effect of (110) film is expected due to larger Bi substitution.

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