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Structural and magnetic characteristics of bismuth substituted holmium iron garnet

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We present the results of X-ray diffractometer (XRD), vibrating sample magnetometer(VSM), and the Mössbauer experiments on the bismuth substituted holmium iron garnet. In zero field cooled magnetization of $Ho_2Bi_1Fe_5O_{12}$ shows typical compensation phenomenon and its temperature is 80 K. But, in field cooled magnetization of $Ho_2Bi_1Fe_5O_{12}$ shows negative magnetization below compensation temperature. From the analysis of VSM hysteresis loop at room temperature, the saturation magnetization and coercivity of the sample are 15.54 emu/g and 33.33 Oe, respectively. The Néel temperature (T_N) was determined to be 650 K by Mössbauer spectroscopy. Compare with results of $Tb_2Bi_1Fe_5O_{12}$, $Ho_2Bi_1Fe_5O_{12}$ has larger saturation magnetization, higher T_N, and lower coercivity than $Tb_2Bi_1Fe_5O_{12}$. These phenomena can be explained by influence of the Bi ions on the superexchange interaction between *a-d* sublattices.

1 Introduction

Bismuth-substituted heavy rare-earth iron garnet materials have attracted much attention in optical communication industries due to their small temperature coefficient of Faraday rotation, low optical absorption, and a low magnetic field for saturation [1]. Especially, $(HoBi)_3Fe_5O_{12}$, and $(TbBi)_3Fe_5O_{12}$ have received much attention for the communication systems devices in the wavelength range of 1.3~1.6 μm [2]. $(TbYbBi)_3Fe_5O_{12}$ has low faraday rotation wavelength coefficient and faraday rotation temperature coefficient could be obtained due to the compensation effect [3]. It is well known that Bi^{3+} ions and rare-earth (RE) ions enhance magneto-optical activity in RE iron garnets [4]. The large splitting of the excited-state induced by the large spin-orbit coupling of the Bi^{3+} ions was responsible for the Faraday rotation enhancement [5]. In the RE iron garnet, the bismuth raises the Néel temperature, which describes that this behavior has been attributed to influence of the Bi ions on the superexchange interaction between *a–d* sublattices [6]. Heavy RE iron garnet has canted magnetic structure which described as a "double umbrella structure" at low temperature. The heavy RE ion spins form a double cone around the [111] axis, and these spin affect to the iron set of 16*a* site [7]. Intricate behaviour of the elastic properties as a function of temperature between 4.2 and 300 K has been observed and ascribed to the combined effects of the appearance of a double-umbrella magnetic structure and a rhombohedral lattice distortion that sets in below the compensation temperature [8]. The materials related to the negative magnetization have been reported that the net magnetization has negative value at low temperature under field cooled condition for $Tb_2Bi_1Fe_5O_{12}$ [9], and $Ho(Fe_{0.6}Mn_{0.4})_{12}$ system [10]. We observed negative magnetization below the compensation temperature in $Ho_2Bi_1Fe_5O_{12}$ under field cooled condition.

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