Effect of $BiFeO_3$/Epoxy Resin Composite Thickness on Gigahertz Microwave Absorption Properties

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Abstract: The microwave absorption properties of multiferroic $BiFeO_3$ (BFO) epoxy resin composite with different thicknesses have been investigated. The $BiFeO_3$ nanoparticles were synthesized by using high energy ball milling (HEBM). The $BiFeO_3$ powders 70% by weight were mixed with epoxy resin as a matrix to form a composite with verified thicknesses of 1 mm, 2 mm and 3 mm. XRD was used to identify the phases and structures of the sample. The room temperature of magnetic characteristics of BFO composite was analyzed by using a vibrating sample magnetometer. The reflection loss value for the purpose of absorption performance was measured in the frequency range 8-18 GHz using a network analyzer. The absorption performances of different thickness of BFO epoxy resin composites were compared and analyzed. The results revealed that BFO epoxy resin composites with 3 mm thickness exhibited higher absorption performance with RL_{min} of –40.5 dB over a 1.31 GHz bandwidth (corresponding to RL below -10 dB).

Keywords**:** Reflection loss, magnetic, multiferroic, absorption

INTRODUCTION

Multiferroic $BiFeO_3$ (BFO) is a fascinating material by owing the combination of ferroelectricity and magnetic order at room temperature [1]. BFO offers wide potentials for magnetoelectronic response applications including as microwave absorbing materials due to its magnetoelectric coupling in single phase of the material [2]. The magnetic losses and dielectric losses were expected to equivalently contribute to the microwave absorption. An ideal absorber that practical used for applications are desired to have light weight, thin thickness, high EM absorption in broad band frequency covered and tunable absorption frequency [3]. In this study, the microwave absorption properties of BFO/epoxy resin composite with various thicknesses were evaluated. The matching relation among the complex permittivity, complex permeability, frequency and the thickness of the materials is the fundamental approach for optimizing the absorbing materials performances [4]. The minimum absorber thickness and the frequency in the matching situations are defined as matching thickness (d_m) and matching frequency (f_m) respectively. The reflection loss (RL) is measured for different thicknesses to obtain the optimum thickness, which shows the maximum absorption.

MATERIALS AND METHODS

The high purity powders of Bi_2O_3 (99.9%) and Fe_2O_3 (99.5%) were used as raw materials and were weighed according to stoichiometric equations. Nanopowders of $BiFeO_3$ were prepared via high energy ball milling (HEBM) by using a SPEX 8000D dual-drive mechanical alloying for 6 h with post heat treatment at 775 °C. The nanopowders with 70% weigh ratio then were mixed with epoxy resin polymer. BFO/epoxy resin composite were fabricated by using the standard waveguide rectangular mould for X and Ku band with inner dimension of 23 x 10 mm and 15 x 7 mm respectively at fixed thicknesses of 1, 2 and 3 mm. The phase and structure analysis were performed using a X-Ray Diffractometer (XRD). A transmission electron microscope (TEM) was used to determine the particle

size distribution and scanning electron microscope (SEM) was used to study the morphologies of the composites. The magnetic properties were measured using a vibrating sample magnetometer (VSM Lakeshore model 7407). The absorption performances of different thicknesses of samples were investigated via a PNA network analyzer N5227A by using the transmission/reflection line method. The complex dielectric and magnetic parameters were computed by solving the conversion of S parameter equation using an Agilent Technologies 85071E Materials Measurement Software.

RESULTS AND DISCUSSION

Fig.1 shows the *RL* versus frequency of verifying thicknesses of BFO composite sample. From the result, the *RL* decreases while increasing the thickness of the sample from 1 to 3 mm. A minimum *RL* value of -40.5 dB indicating the optimum microwave absorption was obseved at 11.5 GHz with a matching thickness of 3 mm. There is another matching frequency of 9.2 GHz with minimum *RL* of -26.0 dB in which the total for both minimum *RL* bandwidth covered up over 1.31 GHz (corresponding to RL below -10 dB). So, it can be concluded that BFO/epoxy resin composite with matching thickness of 3 mm can be introduced as a good potential microwave absorber.

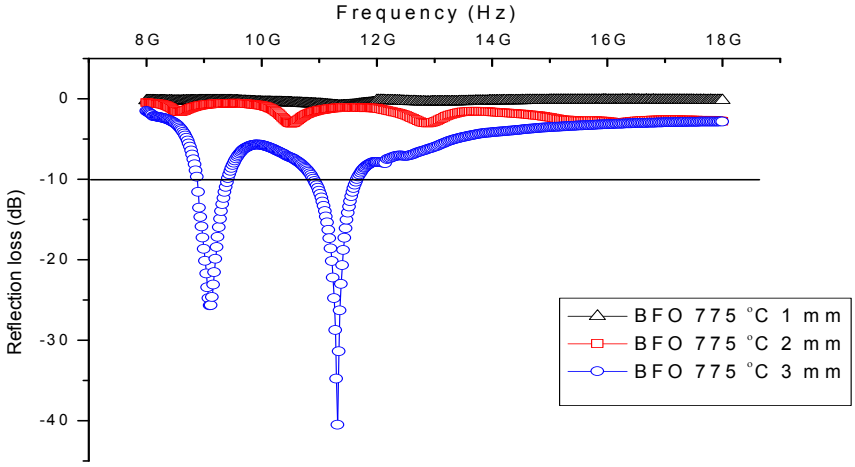

Fig. 1. Reflection loss characteristics of $BiFeO_3$ epoxy resin composites for various thickness

CONCLUSIONS

The thickness of the BFO/epoxy resin composite is affecting the performances of EM absorption. By increasing the thickness of sample until 3 mm, the higher absorption ability was achieved with minimum *RL* of -40.5 dB over a 1.31 GHz bandwith, showing that BFO composite have great potential as a microwave absorbing materials.

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