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Combination of various grain sizes from nano to micron in polycrystalline holmium manganite ($HoMnO_3$) as potential microwave absorbing application

M. M. Syazwan[1] · A. N. Hapishah[2] · I. R. Ibrahim[3] · S. F. Nabilah[2]

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Abstract

The combinations of various grain sizes from nano to micron in polycrystalline holmium manganite ($HoMnO_3$) as potential microwave absorber were investigated. $HoMnO_3$ was prepared via high energy ball milling pursued by sintering process. The phase analysis confirmed that the formation of hexagonal holmium manganite, $HoMnO_3$ along with small amount of orthorhombic holmium dimanganese pentaoxide, $HoMn_2O_5$. SEM micrographs indicated larger grain size as the sintering temperature increased. Explicitly, $HoMnO_3$ provides an electromagnetic (EM) wave absorption characteristics and it was found that $HoMnO_3$ sample have a potential as an efficient microwave absorber which exhibited the maximum reflection loss value of—23.4 dB at 8.5 GHz. This study advocates that by combining different grain size (nano and micron size) would contributed an enhancement value of microwave absorption.

1 Introduction

Microwave absorbing material are in use since long, both in civil and military applications, on account of their ability to eliminate also reduce an electromagnetic wave pollution and radar signatures. Over the last few decades, researchers have showing their scientific effort and interest to develop high-efficiency and high-potential microwave absorbing material. They had discovered different types of materials such as magnetic loss material, conducting polymer material, dielectric loss material, carbon based materials, 2D materials (graphene, MXene), manganites and etc. on their composites to achieve microwave absorber with desired properties [1–15]. Due to various materials testing in order to produce a potential microwave absorbing material has motivated this research work by employing multiferroic manganites as microwave absorber. Hexagonal manganites are class of manganites and represented by the general formula of $RMnO_3$ where ($R = Sc^{3+}$, Y^{3+}, Ho^{3+}, Er^{3+}, Tm^{3+}, Yb^{3+}, Lu^{3+}) is typically a rare earth ion with space group $P6_3cm$ [16, 17]. These rare earth manganites crystallize in hexagonal structure possess magnetoelectric properties, which make them attractive for researchers which is expected could be an approach to acquire an impedance matching characteristic in order to attain excellent microwave absorption capacity [18–20]. Besides that, the particular electronic structure and unusual electromagnetic characteristics of the manganites indicate that it has high applications as microwave absorption materials [21]. The crystal structure of $HoMnO_3$ material is shown in Fig. 1. In this structure, a MnO_5 trigonal bipyramid was formed by one manganese (Mn) atom and five contiguous oxygen (O) atoms where each Mn atom subjugates the middle of a triangular bipyramid whose vertices are O atoms. The rare-earth ions are placed in layers flanked by the bipyramid sheets. This structure is an alternative assembling of rare-earth atom and MnO_5 layers alongside the hexagonal *c*-axis.

The MnO_5 bipyramids stake their corners with adjacent bipyramids to build a triangular lattice within the basal *ab* plane, where each O ion acquaintances three Mn ions, and each Mn ion is bounded by three O ion (Fig. 1a). The Mn atoms create a frustrated spin ordering in this triangular arrangement. The Mn sublattice has a six-fold symmetry entirely since one Mn

✉ M. M. Syazwan
syazwanmustaffa89@gmail.com

1 Department of Physics, Faculty of Science, Universiti Putra Malaysia, UPM, 43400 Serdang, Selangor, Malaysia

2 Functional Devices Laboratory (FDL), Institute of Advanced Technology, Universiti Putra Malaysia, UPM, 43400 Serdang, Selangor, Malaysia

3 Materials Synthesis and Characterization Laboratory (MSCL), Institute of Advanced Technology, Universiti Putra Malaysia, UPM, 43400 Serdang, Selangor, Malaysia