$DyMnO_3$, $GdMnO_3$, $HoMnO_3$, $TbMnO_3$ and $YMnO_3$ Multiferroic Materials and its Applications: A Review

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Abstract: The multiferroic material combines the electrical and magnetic phases in a single phase. Due to the fact that there is a coupling between two phases, these materials are the materials of choice for the development of new technologies. This article outlines the applications of this class of materials along with the fundamentals of the materials like $DyMnO_3$, $GdMnO_3$, $HoMnO_3$, $TbMnO_3$ and $YMnO_3$.

Keywords: Multiferroics, $DyMnO_3$, $GdMnO_3$, $HoMnO_3$, $TbMnO_3$, $YMnO_3$, Applications

I. INTRODUCTION

In a specific temperature range, multiferroic materials show ferroelectric, ferromagnetic, and ferroelasticity properties jointly [1]. A new phenomenon known as the magnetoelectric effect, in which an external magnetic field causes polarisation and an electric field induces magnetization in the substance, due to the combination of ferroelectric and magnetic structuring [2]. The multiferroic materials and multiferroic nanomaterials have number of useful applications in various fields such as less power consumption devices [3], microwave devices [4], switching devices [5], telecommunications, data storage [6], storage and sensors [7], for drug delivery in medical sector [8].

These materials have attracted enormous attention because of their probability in number of device formulation and applications.

II. MULTIFERROIC MATERIALS:

The $DyMnO_3$, $GdMnO_3$, $HoMnO_3$, $TbMnO_3$ and $YMnO_3$ materials shows multiferroic properties in which both electric and magnetic parameters exist together in a single phase.

2.1 $DyMnO_3$

The $DyMnO_3$ is a multiferroic material. At room temperature, the multiferroic $DyMnO_3$ crystallizes in an orthorhombic perovskite phase [9]. Bhoi et.al. [10] reported the formulation of $DyMnO_3$ single phase sample using acrylamide polymer gel template technique and observed that, the obtained sample crystallizes in an orthorhombic phase. Tripathy et. al. [11] reported the formulation of nanoceramics (1-x)$BiFeO_{3-x}D_yMnO_3$ using auto-combustion method and observed that, with increasing doping level the magnetization also increases at room temperature. Harikrishnan et.al. [12] used the optical floating zone method for the formulation of $DyMnO_3$ as well as Sr doped $DyMnO_3$ materials. Magesh et.al. [13] reported the formulation of pure and doped $DyMnO_3$ samples via solid state reaction. Dyakonov et.al. [14] reported the synthesis of $DyMnO_3$ polycrystalline materials using solid-state reaction and observed that, the orthorhombic structure of samples. Semenov et.al. [15] reported the formulation of $Dy_{1-x}Ho_xMnO_3$ samples at different doping concentrations by applying flux technique. Wang et.al. [16] reported the preparation of $HoMnO_3$ and $DyMnO_3$ samples via hydrothermal method and observed that, the samples were crystallized in an orthorhombic phase.

2.2 $GdMnO_3$

The $GdMnO_3$ is another multiferroic material. At room temperature, bulk $GdMnO_3$ possesses an orthorhombic phase [17]. Ibrahim et.al. [18] reported preparation of Eu incorporated $GdMnO_3$ ceramics by employing solid state reaction technique. Negi et.al. [19] reported the nanoparticle formulation of $GdMnO_3$ material using sol gel method and this powder is carried out for pellet formation and finally the pellets are used as target for thin film deposition using pulse laser deposition. Wang et.al. [20] reported the formulation of $GdMnO_3$ nanoparticles using polymerized complex method and observed that, the prepared nanoparticle has an orthorhombic structure. Andreev et.al. [21] reported the $GdMnO_3$ targets synthesis using solid state reaction, thereafter, deposition of $GdMnO_3$ films by employing magnetron sputtering. Sarkar et.al. [22] reported the preparation of Li doped $GdMnO_3$ materials using solid state reaction. Solanki et.al. [23] reported the nanoparticles preparation of $GdMnO_3$, $HoMnO_3$ by employing sol gel technique and observed that, the $GdMnO_3$ have orthorhombic phase as well as $HoMnO_3$ have hexagonal crystal structure. Modi et. al. [24] reported the preparation of $GdMnO_3$ ceramics by solid-state reaction method. Yang-Hsiang Tung et.al. [25] reported the nonfoods formulation of $GdMn_2O_5$ by hydrothermal method.

2.3 $HoMnO_3$

The $HoMnO_3$ is also an multiferroic material. In the hexagonal $HoMnO_3$ the order parameters are naturally related via Ho–Mn exchange and anisotropy couplings [26]. Dubourdieu et.al. [27] reported the formulation of $YMnO_3$ as well as $ReMnO_3$ (Re = Tb, Dy, Ho) thin films on a substrate by metal organic chemical vapour deposition. Murugavel et. al. [28] reported the preparation of $HoMnO_3$ thin films via pulse laser deposition over Pt(111)/Al_2O_3(0001) and yttrium stabilized zirconia (111) substrates. Ibrahim et.al. [29] reported formulation of Cr doped $HoMnO_3$ samples using solid state reaction and observed that, the samples crystallizes in an orthorhombic phase. Dong et.al. [30] reported the h-$HoMnO_3$ powder formulation using solid state reaction. Tsai et.al. [31] reported the formulation of $LuMnO_3$ and $HoMnO_3$ pellets via solid state reaction and these pellets were carried out as a target material for thin film deposition using pulsed laser deposition. Lorenz et.al. [32] reported the samples preparation of $HoMnO_3$ and $YMnO_3$ by using high-pressure conditions.

2.4 $TbMnO_3$

The $TbMnO_3$ also exhibits a multiferroic properties. The compound $TbMnO_3$ at room temperature possesses a distorted perovskite crystal structure having orthorhombic symmetry [33]. Dias et.al. [34] reported the preparation of nanostructured $TbMnO_3$ samples using high-energy ball milling. Xu et.al. [35] reported the synthesis of pure, Bi doped TbMnO3, as well as Bi and Fe codoped $TbMnO_3$ samples using solid state reaction. Hu et.al. [36] reported the formulation of $TbMnO_3$ thin films by pulsed laser deposition. Lee et.al. [37] reported the deposition of hexagonal $TbMnO_3$ films by applying pulsed laser deposition (PLD) technique.

Kirby et.al. [38] reported the synthesis of $TbMnO_3$ thin film using pulsed laser deposition technique. Venkatesan et.al. [39] reported the preparation of $TbMnO_3$ thin films by pulsed laser deposition. Gupta et.al. [40] reported the formulation of pure $BiFeO_3$, $TbMnO_3$ as well as $BiFeO_3$-$TbMnO_3$ composite materials using solid-state reaction. Acharya et.al. [41] reported the synthesis of $TbMnO_3$ nanorods using microwave-assisted chemical route. Acharya et.al. [42] reported the formulation of $TbMnO_3$ samples using hydrothermal synthesis.

2.5 $YMnO_3$

The $YMnO_3$ also exhibits a multiferroic properties. The multiferroic $YMnO_3$ manifests a hexagonal structure having ferroelectric transition temperature around 900 K as well as the antiferromagnetic transition around 90 K [43]. Kumar et.al. [44] reported the formulation of $YMnO_3$ samples using solid state reaction through microwave assisted radiant heating. Nie et.al. [45] reported the preparation of (1-x)$BiFeO_3$-$_x$$YMnO_3$ targets via solid state method and the thin films deposition by pulse laser deposition. Han et.al. [46] reported the formulation of $YMnO_3$ nanoscale materials via modified Pechini approach. Bogusz et.al. [47] reported the synthesis of $YMnO_3$ thin films using pulse laser deposition.

CONCLUSION:

The present article reports the basics about the different fundamental multiferroic materials such as $DyMnO_{3,}$ $GdMnO_{3,}$ $HoMnO_{3,}$ $TbMnO_3$ and $YMnO_3$ materials. These material displays both electric and magnetic interaction simultaneously. This article also describes the numerous applications of these materials as well as the present research on this class of materials.

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