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Research articles

Magnetic and dielectric properties of Nd–Mn substituted Co_2Y-hexaferrites

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ABSTRACT

Designing the new multifunctional ferromagnetic materials for multilayer chip inductor has attracted widespread interest in recent years. Co_2Y strontium hexaferrites with composition of $Sr_{2-x}Nd_xCo_2Fe_{12-y}Mn_yO_{22}$ (for X = 0.00–0.1, Y = 0.00–1.0) were fabricated by the simple economical sol-gel autocombustion method. The surface morphology of the synthesized materials was investigated by using scanning electron microscopy and the particles were in plate-like shape. The magnetic properties calculated through hysteresis loops which were measured by vibrating sample magnetometer showed that the fabricated materials have typical properties related to ferromagnetic materials. The observed values of saturation magnetization were found in the range of 64.43–35.11 (emu/g). The observed decline in the values of magnetic parameters with the substituents (Nd-Mn) resulted due to suppression of magnetic superexchange interactions. The dielectric parameters including impedance and modulus investigation reveal that there are grains where the grain boundaries might play an important role in the conduction mechanism and the same may also be concluded from semicircle shape of Cole-Cole plots.

1. Introduction

Since 1950, significant achievements have been made for the oxides ferrimagnetic hexagonal materials owing to their inherent high values of resistivity, magnetization and permeability. Due to these properties, such materials are considered to be excellent candidates for their potential applications in the fields of magnetic recording media, high frequency microwave devices, absorber and high density storage devices [1,2]. Consequently, the hexagonal ferrites have been exfoliated among the researchers on academic as well as industrial scale over the past decade. The hexagonal ferrites are advantageous over the other magnetic materials for their distinct properties *i.e.*, mechanical stability and magnetic anisotropy. The Y-type hexaferrites are classified as important candidates among the other magnetic materials due to their potential applications in the field of high frequency devices in the GHz ranges. The internal restructuring of magnetic materials by the substitution of divalent or trivalent cations may lead to reorganize the properties of these materials for their potential applications in various devices [3–5]. The Co_2Y strontium hexaferrites have distinct properties like remarkable chemical stability, excellent corrosion resistance, high saturation magnetization, high Curie temperature and suitable values of coercivity [6]. The structural characteristics, surface morphology, magnetic properties and polarization of the fabricated hexaferrite nanoparticles eventually rely on fabrication route, chemical composition, annealing temperature and time as well as employed precursors. Specifically, attention has been diverted towards the fabrication of new hexagonal ferrites and effect of various substituents on their magnetic properties. The introduction of rare earth (RE) cations may improve the magnetic and dielectric properties due to interaction of 4f electrons. The electrical polarization of the dielectric materials are manipulated by the dielectric characterization which may be done by the application of applied electric field in terms of frequency. Currently, numerous efforts have been made to improve the dielectric properties of the hexagonal ferrites by combining them with suitable cations and their extant of aggregation. In recent years, a lot of attention has been drawn on the substitution of rare earth cations at Sr and Fe sites in order to improve the magnetic and microwave properties [7,8].

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Both the magnetic and dielectric parameters (electric permittivity and impedance) gather increasing interest for MLCI. The reason for choosing the Nd-Mn is that firstly our purpose was to reduce the dielectric parameters such as impedance so that the materials can be used for multilayer chip inductors as such devices required highly resistive materials. Secondly, the electronic configuration of Nd^{3+} showed that it has three unpaired electrons while strontium has zero unpaired electrons which we also expected that it will improve the magnetic properties. The reason for Mn^{2+} along with Nd is that the manganese ion has five unpaired electrons as that of ferric ion. The transfer of electrons from Mn^{2+} to Mn^{3+} is not so easy as compared to ferrous to ferric ions which also help in reducing the conductivity as well as the dielectric parameters. The ionic size of strontium and neodymium is also comparable.

The impact of Nd-Mn co-doping for Co_2Y strontium hexaferrites materials synthesized via sol-gel autocombustion method in order to describe variation in impedance and saturation magnetization, remanence and role of grains in coercivity variation. In the present investigation, the decrease in the values of the impedance justify

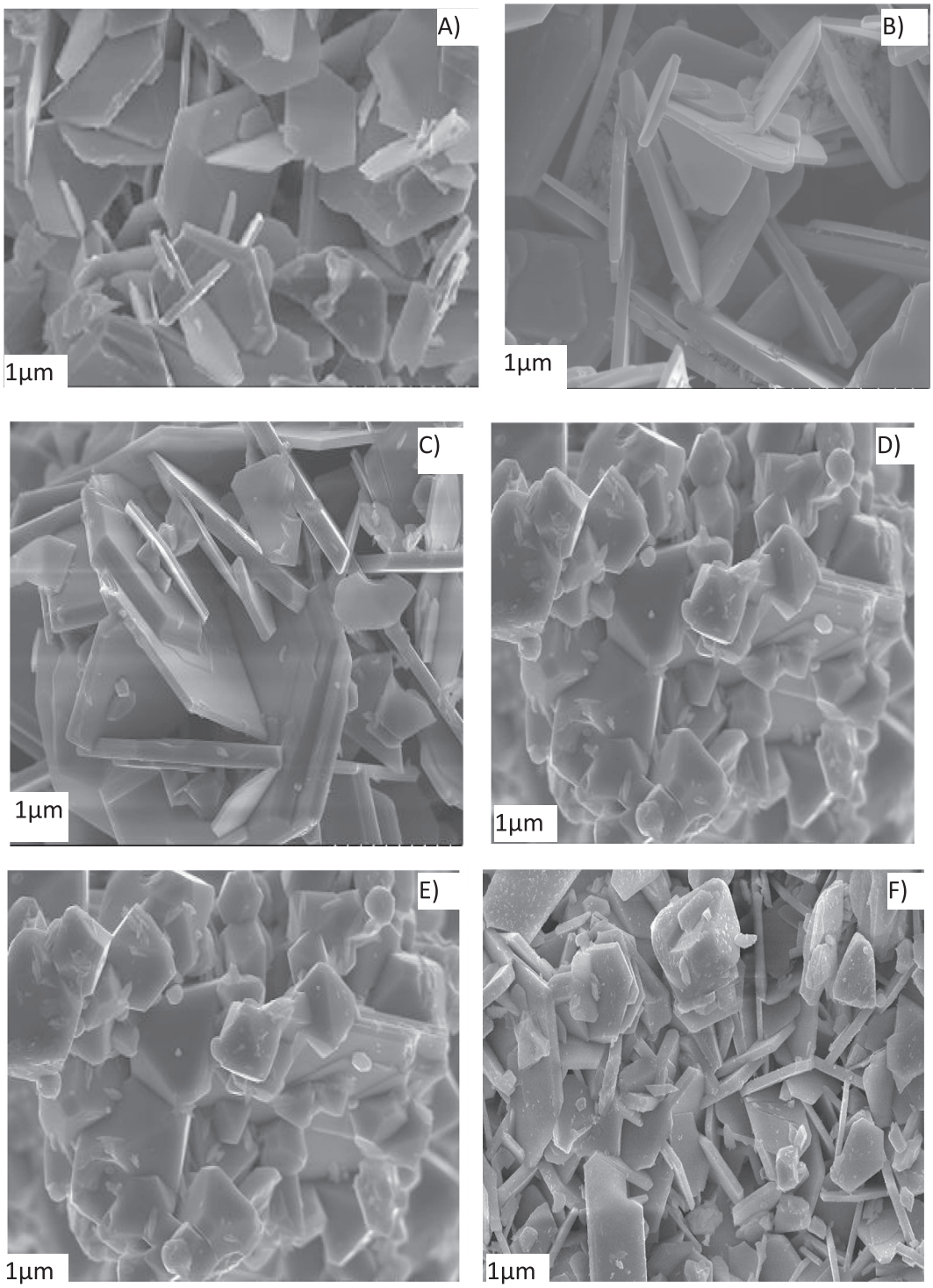

Fig. 1. (A–F) Images for $Sr_{2-x}Nd_xCo_2Fe_{12-y}Mn_yO_{22}$ (X = 0.00–0.1, Y = 0.00–1.0) samples.