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Studies on Structural and Radar Invisibility Capability of Nano Structured Doped Perovskite Manganite Materials

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ABSTRACT

The stealth technology and functional materials developed for air combat systems are applicable to ground and naval systems as well with modification to suit their function and environmental requirements. In stealth technology, the minimization of electromagneticsignature can be realized in several ways which include stealth shaping design, radar absorbing material (RAM), and radar absorbing structures (RAS). Other side Nanostructured radar absorbing materials (RAMs) are experiencing steadily increasing interest because of their fascinating functional properties and various applications compared with the bulk or microsized counterparts. Under the threat perception, enemies detection capabilities through surveillance, reconnaissance or guided weapon system, signatures suppression by way of hiding, blending, and deception i.e. creating false signature of real targets are essential to enhance their survivability. In this communication we have successfully synthesis nanostructure perovskite manganite $La_{0.7}Ba_{0.3}MnO_3$ (LBMO) materials low cost chemical solution technique. The structural properties have been characterised by X- ray diffraction technique, XRD pattern shows single phase and polycrystalline structure of LBMO. The complex permittivity and permeability of the sample were measured by microwave vector network analyzer in the frequency range of 2- I8 GHz. The microwave absorption capability of nano structured LBMO have been discussed.

KEYWORDS: Radar absorbing structure, radar absorbing materials, LBMO, stealth material

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INTRODUCTION

Stealth materials that are used as military objects are specially designed with reduced or tailored reflectivity, emissivity or absorbance and can either be used in the structure of the object or as surface coatings. Transition metal oxides of the ABO_3 type display varieties of electronic transport and magnetic properties [1-4]. Recently there has been renewed interest in physical properties of oxides with the general chemical formula $Ln_{1-x}A_xMnO_3$ (Ln= La Pr, Nd, etc., and A= Ca, Sr, Ba, Pb, etc.) since these materials show some good electronic transport and magnetic properties and colossal magneto resistance (CMR).The synthesis of perovskite oxide or some oxide are also one of the key factor to tailoring the electrical and magnetic properties of oxide materials, various many research papers are produce in vicinity of tuning synthesis parameter or synthesis technique and investigated effect of it on oxide materials[5].The Radar Absorbing materials RAM also new class of materials and have wide application in various industries, RAM absorbs the incident EM wave or cancels it by interference and ohmic loss, the absorbed energy is transferred to heat. Due to these non-reflected radar waves, Radar absorbing materials (RAM) and radar absorbing structures (RAS) are play vital to reduced signature for detection. Typically, RAM and RAS are used in defence applications and in commercial communication activities that require the absorption of electromagnetic interference (EMI) and radio frequency interference (RFI) with the double exchange Interaction model, the peripatetic carriers in the $Ln_{1-x}A_xMnO_3$(A= divalent ions such as Ca^{2+}, Ba^{2+} and Sr^{2+})provide the mechanism for ferromagnetic interaction between Mn^{3+} and Mn^{4+} ions. Screen printing method (Thick film technology) is a low cost method, highly conducive to planarization and useful for miniaturized high-frequency components. The permittivity and permeability are vital properties of any medium, which define how the electromagnetic waves propagate through any medium [7]. The approaches for material property characterizations at microwave frequencies are based on transmission lines and the resonant structures developed from transmission lines [8]. The microwave properties of materials can be classified into non-resonant methods and resonant methods [9]. The typical method of examining the microwave properties of overlaid materials is using patterning simple devices like straight resonator [10], ring resonator [6, 11], microstripline [12] etc. and measuring its response at microwave frequency and evaluating its properties. In this communication we have report synthesise of nano structured $La_{0.7}Ba_{0.3}MnO_3$ by advance chemical synthesise technique and characterise their structural and microwave absorption properties.

EXPERIMENTAL DETAILS

The nano structured $La_{0.7}Ba_{0.3}MnO_3$materials were synthesized by cost effective Chemical Solution gel via acetate route method. High purity Lanthanum Acetate [$La(CH_3CO_2)_3 \times XH_2O$], Barium Acetate [$Ba(CH_3CO_2)_3 \times XH_2O$]and Manganese Acetate [$Mn\ (CH_3CO_2)_2 \times 4H_2O$] were taken as starting materials in appropriate stoichiometric ratio, all the starting materials were pre heated at 120^{o}C for reduces humidity effect. The precursor solution was ready by dissolving the constituents in double distilled water (DDW) and acetic acid (AA) with desired composition. The optimum ratio of DDW and AA of 1:1 was maintained in proper volume to yield of 0.4M solution. Then, ethylene glycol was added to make gelation Excess ethylene glycol can prevent nucleation and inhibit the growth of the nuclei, which can induce a preferable size distribution. The solution was stirred at room temperature for 5 h and heated at 95°C until a gel was formed. This gel was further dried at 130 °C and grounded into fine black powders. The obtained powder was calcined at 500^{o}C for 6hrs. Finally, the material (in pellet form) was sintered at 700^{o}C, 900^{o}C, and 1100^{o}C for 2hrs in air atmosphere. The structure properties of $La_{0.7}Ba_{0.3}MnO_3$ Sample analysed by X-ray diffraction (XRD) patterns, the microwave absorption capability of nano structured $La_{0.7}Ba_{0.3}MnO_3$was carried out by HW 1-Model Micro-Wave Network Analyzer.

RESULTS AND DISCUSSION

Structural characterizations have been carried out through X- ray diffraction method. XRD patterns of LBMO nanoparticles calcined at 700^{o}C, 900^{o}C, and 1100^{o}C are shown in figure 1. We have estimated the average grain size (D) of those samples through the Scherer's formula employing the equation $D = 0.89\lambda/(\beta\cos\theta\ )$, here β is the full width at half maximum (FWHM) of a particular XRD peak of LBMO samples. The crystalline size of the sample calculated from the Scherer's formula are 25nm, 53nm and 65nm at 700^{o}C, 900^{o}C, and 1100^{o}C respectively. Furthermore the XRD pattern shows the LBMO samples sintered at various temperatures possess orthorhombic structure, polycrystalline structure without any detectable impurity in measure range of X-ray incident angle 2θ, 20^{o}to 70^{o}C. The XRD pattern reveal no shifting of the peak observed in all the samples of LBMO sintered at different sintering temperature indicating there is no measure strain or stress produce in the structure of all the samples, which suggest that during the synthesis of the all samples by mentioned chemical method we get the uniform structural growth of nano structure LBMO, only grain size get modified (increases) by sintering temperature.

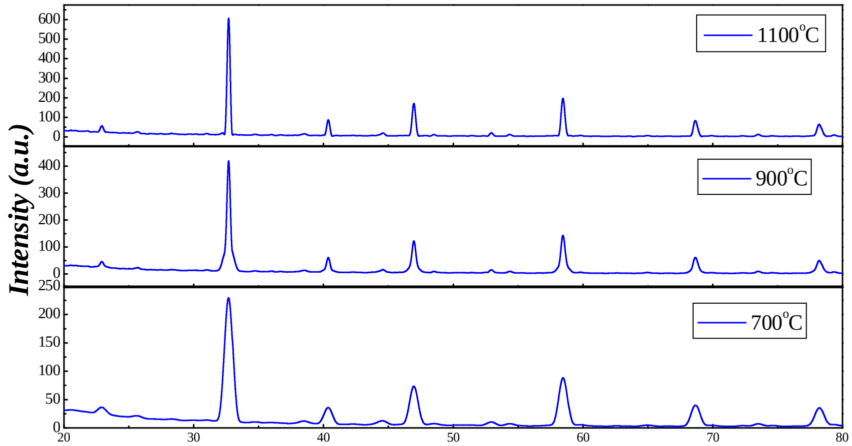

Fig. 1. XRD patterns of a series of $La_{0.7}Ba_{0.3}MnO_3$ nanoparticles calcined at700°C, 900°C, and 1100°C

Fig.2 shows the experimental data of frequency dependence of the microwave property of $La_{0.7}Ba_{0.3}MnO_3$ having the coating thickness of 3mm. The absorption curve shows decrement in the peak value from 20.0 db, the absorption continuous decreases with increasing sintering temperature from 700°C to 1100°C. The microwave-absorbing frequency bandwidths defined as the frequency width in which the absorption is larger than 8 dB are about 8.6 GHz, 8.9 GHz and 9.2 GHz for the samples sintered at 700°C, 900°C, and 1100°C respectively.Such wide absorption bandwidths and high absorption loss peaks indicate the attractive potential microwave applications. Recently reported measurements of the microwave losses in micro size powders of several manganites. It was shown that for $La_{0.7}Ba_{0.3}MnO_3$, the zero-field absorption exhibits a large increase as the temperature drops below a (T_C) which is higher than room temperature, the grain size also affect the critical temperature of the manganite was very well understood by various scientific group [1], the critical temperature decreases with decreasing nano grain size. We measure the critical temperature of LBMO increases from 305K to 315K with sintering temperature 700°C to 1100°C and all are above the room temperature. It is naturally considered that the losses are related to ferromagnetism, the formation of magnetic domains, and the resonance absorption of the moving magnetic domains and spin relaxation in the high frequency alternating electromagnetic fields. The enhancement of microwave absorbance is mainly dominant by magnetic and dielectric loss of the samples, here the microwave absorbance increases with decreasing sintering temperature or decreasing grain size which can be discussed in vicinity of defects availability in materials by grains and grain boundaries. From the discussion of XRD the grain size increases with increasing sintering temperature, the smaller grain size is shows enhancement in to the ferromagnetic properties of materials furthermore the smaller grains have large grain boundaries consequently more defects in structure which leads higher dielectric loss, thus the large microwave absorption observe in the lower sinter temperature and decreases with increasing sintering temperature.

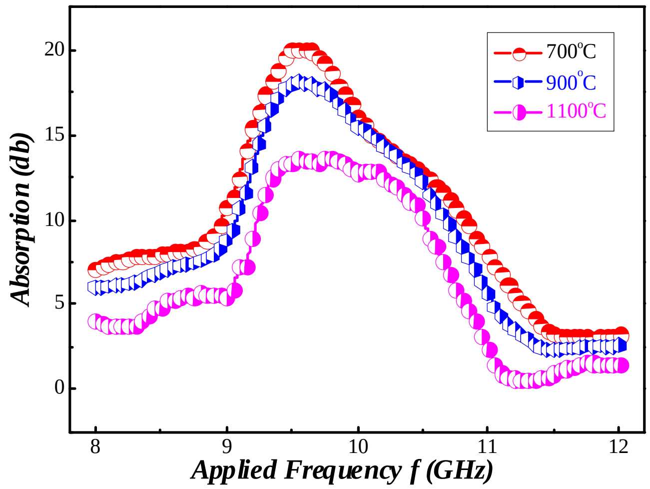

Fig.-2. The microwave absorption versus frequency of LBMO sintered at 700°C, 900°C, and 1100°C

CONCLUSION

In summary, we reported the chemically grown nano structured LBMO materials, the sintering temperature was varied from 700°C, 900°C, and 1100°C to varying grain size of the samples, the structural property from investigated from XRD suggest that the crystalline size increase with sintering temperature. The microwave absorption property were studied in between 8GHz to 12GHz, the lower sintered sample have higher microwave absorption due to high magnetic and dielectric loss by smaller grain size and higher grain boundaries

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