International Journal of Advanced Technology in Engineering and Science
Vol. No.3, Issue 11, November 2015
www.ijates.com
ijates
ISSN 2348 - 7550

ROOM TEMPERATURE COMPLEX IMPEDANCE STUDY OF $0.1NiFe_2O_4$-$0.9ErMnO_3$ NANOCOMPOSITE

Swati Singh[1], P. Dey[2], S. K. Mandal[3]

[1,2,3]*Department of Physics, National Institute of Technology Agartala, Agartala, Tripura, (India)*

ABSTRACT

We have presented complex impedance study of $0.1NiFe_2O_4$-$0.9ErMnO_3$nanocomposite at room temperature. It has been observed that value of complex impedance decreases with increase in frequency. With the application of magnetic field of 1800 Oe, the value of complex impedance decreases. A shift in relaxation peak towards higher frequency have been observed, which may be due to pinning centres of $NiFe_2O_4$ grains.

Keywords: Nanocoposite, Complex Impedance, NFO-EMO

I. INTRODUCTION

With the advancement of technology, the quest for developing multiferroic composite have triggered most of the researchers due to its wide applications, such as magneto-electric (ME) devices, data storage, multiple state memory element and sensors [1]. These coupling devices is used to tune the magnetic properties by varying electric field or vice versa. However, in nature it is very rare and difficult to achieve multiferroic property in a single- phase materials. Even if those are available exhibit weak ME coupling effect and that at very low temperature. Hence, for commercial application it is necessary to achieve strong ME coupling in a single material in a single phase.

Realising the importance of multiferroic composite in the field of electronic industry we have prepared $0.1NiFe_2O_4$-$0.9ErMnO_3$(NFO-EMO)nanocomposite. In this paper we have shown the complex impedance study of NFO-EMOnanocomposite both in presence and absence of magnetic field (1800 Oe). The value of real part of impedance (Z´) decreases in presence of magnetic field. A shift in resonance peak towards high frequency region is observed. This may be due to pinning centre in ferromagnetic NFO grains.

II. EXPERIMENTAL DETAILS

NFO – EMO nanocompositehas been prepared by chemical "pyrophoric reaction process" [2]. The NFO phase were prepared from high-purity $Ni(NO_3)_2$ (97%) and$Fe(NO_3)_3$ (98%) and EMO phase prepared from $Er(NO_3)_2$ (99.9%) and $Mn(CH_3COO)_2$ (99.0%). We have employed aqueous solution of the requisite amount of compounds in stoichiometric proportions with triethanolamine (TEA) being added with these solutions at 1: 4 (metal ion: TEA = 1: 4) ratio separately for NFO and EMO. After adding the TEA, the solution becomes viscous and colloidal. The clear solutions of TEA complexes metal nitrates of those individual compounds of NFO and EMO then are mixed properly in a single container and are evaporated on a hot plate at 180°C with constant stirring. The continuous heating of these solutions causes foaming and puffing. When complete dehydration occurs, the nitrate themselves are decomposed with the evolution of brown fumes of NO_2 leaving

behind a voluminous, carbonaceous, organic based, black, fluffy powders, i.e. precursor powders with the desired metal ions embedded in its matrix. The dried carbonaceous fine powder has been calcined (in air 5 h) at a temperature of 800°C to obtain the required composite phase. We made circular pellets from calcinednano powders and have sintered them for 30 - 45 minutes. The sintering temperatures were same as that of calcination temperatures of the respective nano powders.

Structural characterisations of 0.1NFO- 0.9EMO nanocomposite have been done by X-ray diffraction technique (XRD) (Philips, PW–1729) with monochromatic Cu-K_α radiation. Complex impedance study have been carried out through LCR meter (HIOKI-3532-50 LCR HiTESTER)using 2 probe measurement technique. For such study, we have done electroding using silver paste.

III. STRUCTURAL CHARACTERISATIONS

Structural characterisations have been done through XRD technique for 0.1NFO- 0.9EMO nanocompositeas shown in Fig. 1

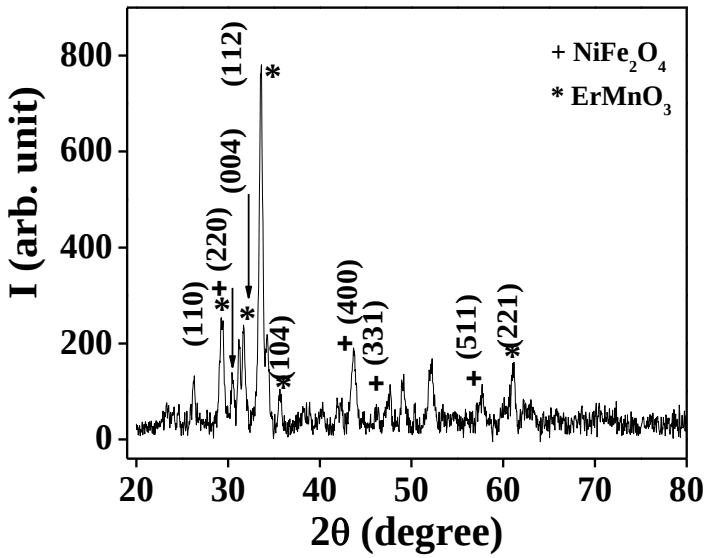

Fig. 1: XRD Patterns for 0.1NFO-0.9EMO nanocomposite.

IV. RESULTS AND DISCUSSIONS

Complex impedance study for 0.1NFO- 0.9EMO nanocomposite in presence and absence of magnetic field (1800 Oe) is shown in Fig. 2. The complex impedance value decreases with increase in frequency. Also in the presence of magnetic field the value of real part of impedance Z′ decreases as compared to absence of magnetic field is shown in Fig. 2 (b). In our measured frequency range, we have observed two resonance peak in Z″ vs. frequency curve. The frequency corresponding to resonance peak is the relaxation frequency (f_o). The resonance peak is found to be shifted towards higher frequency region.Fig. 2 (c) shows theNyquist plotfor NFO-EMO nanocomposite, where blue soild line indicates the shifting of resonance peak towards high frequency region. The peak appear at low frequency is due to grain boundary (R_{gb}) whereas the peak appear at high frequency correspond to grain (R_g) of the sample. The shift in resonance peak may be due to pinning centres in FM NFO

grains, where the magnetic domain walls are pinned. With application of magnetic field, there is depinning of FM domain walls from those grain boundaries pinning centres [3, 4]. Hence the magnetic scattering in the electronic conduction become less. As a consequence of this spin dependent transport enhances, thus resulting in decrease in Z′ in presence of magnetic field.

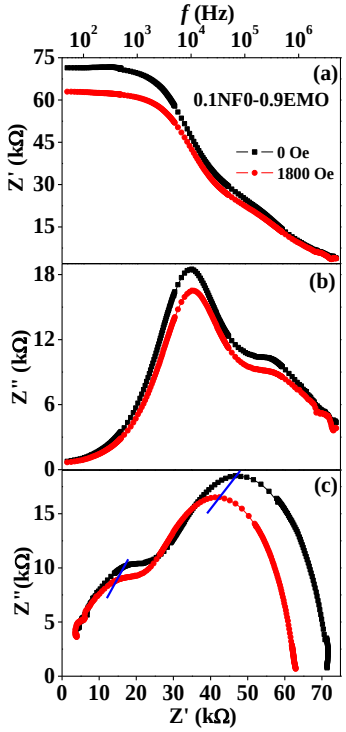

Fig. 2: Complex Impedance spectra for 0.1NFO-0.9EMO nanocomposite

V. CONCLUSION

Complex impedance of 0.1NFO-0.9EMO nanocomposite is found to be decreases with increase in frequency for both presence and absence of magnetic field. Shift in relaxation peak towards higher frequency region may be due to pinning centres of NFO grains. The decrease in Z′ value in presence of magnetic field may be explained as depinning of NFO domain walls from the grain boundaries pinning centres.

VI. ACKNOWLEDGEMENT

We acknowledgeDSTProject (No. SR/FTP/PS-019/2012), Indiaand UGC-DAEconsortium for scientific research Indore, India for providing us some experimental facilities.

REFRENCES

[1] C.-W. Nana, M. I. Bichurin, S. Dong, D. Viehland, and G. Srinivasan, Multiferroicmagnetoelectric composites: Historical perspective, status, and future directions, J. Appl. Phys. 103, 031101 (2008).

[2] S. K. Mandal, P. Dey, and T. K. Nath, Structural, electrical and dielectric properties of La0.7Sr0.3MnO3–ErMnO3 multiferroic composites, Mater. Sci. Eng., B 181, 70 (2014).

[3] P. Dey and T. K. Nath, Effect of grain size modulation on the magneto- and electronic-transport properties of La0.7Ca0.3MnO3 nanoparticles: The role of spin-polarized tunnelling at the enhanced grain surface, Phys. Rev. B 73, 214425 (2006).

[4] R. Debnath, P. Dey, S. Singh, J. N. Roy, S. K. Mandal and T. K. Nath, Magnetically tunable alternating current electrical properties of x La0.7Sr0.3MnO3–(1 −x) ErMnO3 (x = 0.1, 0.3, and 0.5) multiferroicnanocomposite, J. Appl. Phys. 118, 044104 (2015).