Vol II Issue X

ISSN No : 2230-7850

Monthly Multidiciplinary Research Journal

Indian Streams Research Journal

Welcome to ISRJ

RNI MAHMUL/2011/38595 **ISSN No.2230-7850**

Indian Streams Research Journal is a multidisciplinary research journal, published monthly in English, Hindi & Marathi Language. All research papers submitted to the journal will be double - blind peer reviewed referred by members of the editorial Board readers will include investigator in universities, research institutes government and industry with research interest in the general subjects.

Address:-Ashok Yakkaldevi 258/34, Raviwar Peth, Solapur - 413 005 Maharashtra, India
Cell : 9595 359 435, Ph No: 02172372010 Email: ayisrj@yahoo.in Website: www.isrj.net

Indian Streams Research Journal
Volume 2, Issue.10,Nov. 2012
ISSN:-2230-7850
Available online at www.isrj.net

ORIGINAL ARTICLE

FREQUENCY AND COMPOSITION DEPENDENT DIELECTRIC BEHAVIOUR OF CU2+ SUBSTITUTED NANOCRYSTALLINE $NI_{0.8-X}CU_XZN_{0.2}FE_2O_4$ FERRITES

V. V. AWATIA , S. M. RATHOD , MAHESHKUMAR L. MANED AND S. P. KAMBLE

Department of Physics, C. T. Bora College, Shirur Pune,JJT University, Jhunjhunu Rajasthan,
P. G. Department of Physics, Aabasaheb Garware College, Pune, MS, India
Department of Physics, S. G. R. G. Shinde Mahavidyalaya, Paranda
Department of Physics, C. T. Bora College, Shirur Pune.

Abstract:

Dielectric phenomenon have been investigated by synthesizing nano-particles of $Ni_{0.8-x}CuxZn_{0.2}Fe_2O_4$ ferrites wherein (0.8-x)Ni^{2+} ions have been replaced by xCu^{2+} ions (x = 0.0 0.6 with steps of 0.2) by sol-gel auto-combustion technique. The crystal phase of samples was confirmed by employing powder X-ray diffraction technique. The variation of dielectric parameters such as dielectric constant (Ɛ'), dielectric loss (Ɛ") and dielectric loss tangent (tan) as a function of frequency and composition have been investigated. The dielectric behavior showed a typical ferrite nature for all compositions. The loss tangent (tan) measurements conclude that the conduction mechanism in these samples is due to polaron hopping.

KEYWORDS:

Ferrite; Crystal phase; Dielectric properties; Sol-gel auto-combustion.

1.INTRODUCTION:

Recent scientific and technological developments involves use of nanocrystalline magnetic materials specially spinel ferrites. Ferrites are very good dielectric materials and have many technological applications ranging from microwave to radio frequencies. Hence, it is important to study their dielectric behaviour at different frequencies. Ni-Zn ferrite is widely used in many applications, including multilayer chip inductors (MLCIs), microwave components and devices [1–4]. Multilayer chip inductors (MLCIs) have recently been developed as a surface mounting device (SMT) for miniaturization of electronic devices [5, 6]. They are important components for the electronics products, such as cellular phone, notebook computer, video camera, etc. Ni–Cu–Zn ferrite is usually used as magnetic material for MLCIs due to its lower sintering temperature and better properties at high frequency than Ni–Zn ferrite [7].

The present investigation is aimed to study frequency and compositional dependent dielectric properties of nanocrystalline Cu2+ substituted Ni-Zn ferrite prepared by sol-gel auto-combustion technique.

2.EXPERIMENTAL TECHNIQUE:

A spinel ferrite $Ni_{0.8-x}CuxZn_{0.2}Fe_2O_4$ (with x = 0.0, 0.2, 0.4 and 0.6) nanoparticles were prepared by the sol–gel auto-combustion technique from the high purity analytical grade solutions of $Fe(NO_3)_3·9H_2O$, $Cu(NO_3)_2·3H_2O$, $Zn(NO_3)_2·6H_2O$ and $Ni(NO_3)_2·6H_2O$. The citric acid was used as fuel. The weighed amounts of these metal salts were completely dissolved in distilled water and the solution was stirred for

half an hour. This solution was then added to citric acid in such a way that in the final sample, the molar ratio of these nitrates and citric acid become 1:3 respectively. A small amount of ammonia was simultaneously added drop-wise to maintain the pH to 7 with continuous stirring the solution. The samples were then heated at 700 C after confirmation by TG/DTA analysis.

X-ray diffraction pattern of the sample was obtained using Philips X-ray diffractometer (Model PW 3710) using Cu-K*a* radiations. The dielectric constant of the samples was calculated from the capacitance (Cp) and loss factor (tan)?values measured using LCR meter bridge (HP 4284 A) in the frequency range 50 Hz to 1 MHz at room temperature.

3.RESULTS AND DISCUSSION:

3.1Structural analysis:

The phase identification of the prepared nano-materials was examined by X-ray diffraction technique. The typical X-ray diffraction pattern for x = 0.0 is shown in Fig. 1. All the samples show good crystallization, with well defined diffraction lines. The structure can be indexed as a single phase cubic spinel structure with no extra lines corresponding to any un-reacted ingredient. The planes [2 2 0], [3 1 1], [2 2 2], [4 0 0], [4 2 2], [5 1 1], and [4 4 0] in the diffraction patterns confirm the formation of pure cubic spinel ferrite structure.

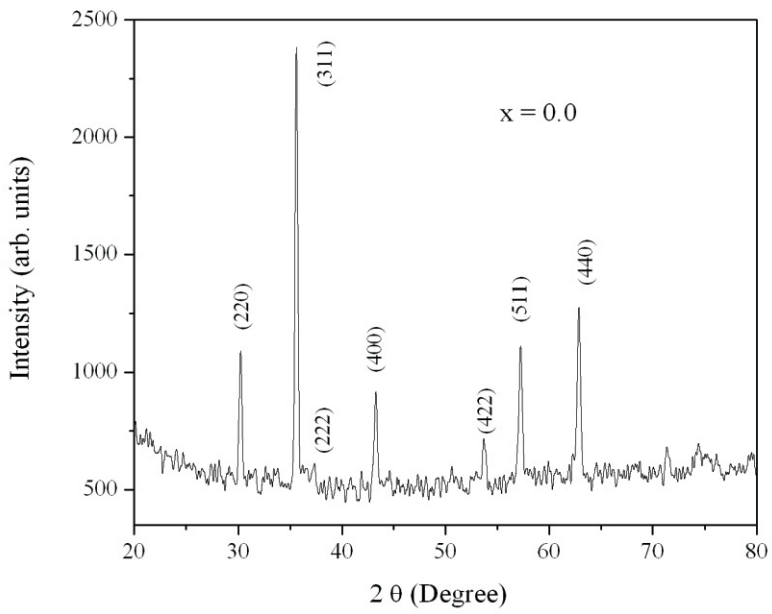

Fig. 1: X-ray diffraction patternfor typical sample of nanocrystalline $Ni_{0.8}Zn_{0.2}Fe_2O_4$ ferrite

3.2Dielectric phenomenon:

Dielectric constant (***ε'***) was calculated as [8]:

$$\varepsilon?? \frac{C_P ?d}{\varepsilon_0 ?A}$$

where, Cp is the capacitance of the pellet in farad, d is the thickness of the pellet in meters, A is the cross-sectional area of the flat surface of the pellet and εo is the constant of permittivity for free space.

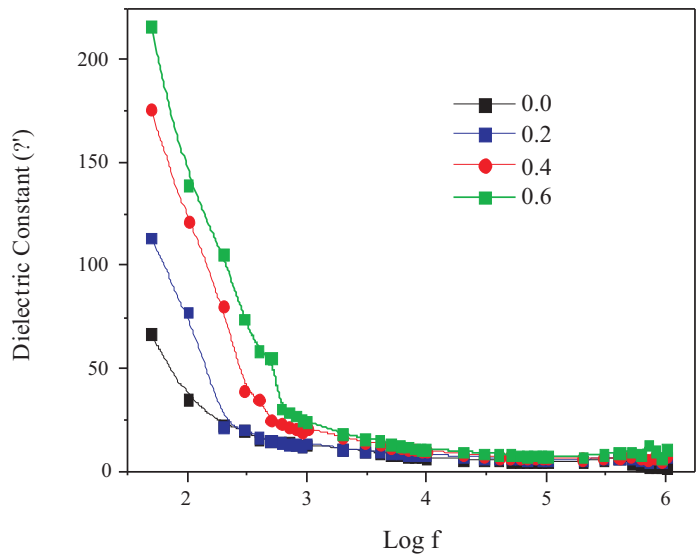

Fig. 2: Variation of dielectric constant (?') with applied frequency (Log f) for nanocrystalline $Ni_{0.8-x}Cu_xZn_{0.2}Fe_2O_4$ (x = 0.0 ? 0.6 with steps of 0.2) ferrite

The dependence of dielectric constant (ℰ') of Cu2+ substituted Ni-Zn ferrite nanoparticles with frequency is shown in Figs. 2. It can be seen that all the samples show frequency dependent phenomena, i.e., the value of decreases with frequency; the decrease is rapid in the low frequency region, while it approaches almost frequency independent behaviour in the high frequency region. polarization in the ferrite is through h a mechanism similar to the conduction process. The presence of Fe^{3+} and Fe^{2+} ions render ferrite materials dipolar. The rotational displacement of dipoles results in orientational polarization. In ferrites, rotation of Fe^{2+} to Fe^{3+} can be visualized as the exchange of electrons between two ions, so that the dipoles align themselves in response to alternating electric field. The polarization at lower frequencies may result from electron hopping between $Fe^{3+}Fe^{2+}$ ions in ferrite lattice. As Cu ions are substituted for Ni ions, the change in structural homogeneity results in the increase of polarization, which results in the increase of dielectric constant.

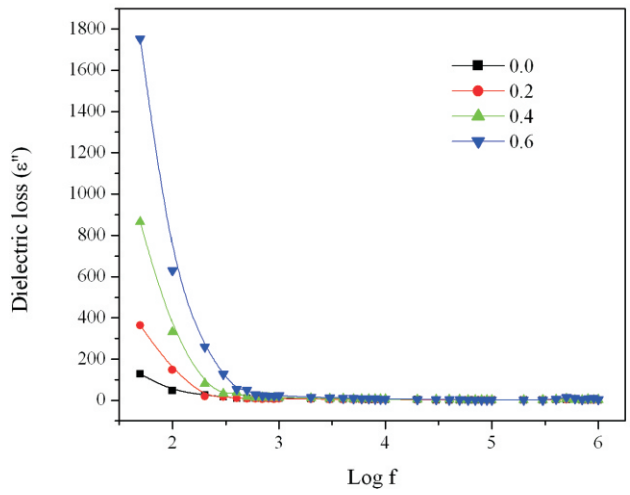

Fig. 3: Variation of dielectric loss (??) with applied frequency (Log f) for nanocrystalline $Ni_{0.8-x}Cu_xZn_{0.2}Fe_2O_4$ (x = 0.0 ? 0.6 with steps of 0.2) ferrite

The variation of dielectric loss (ε") and dielectric loss tangent (tan δ) with frequency is depicted in Figs. 3 and 4 respectively. It is observed that both dielectric loss (ε") and dielectric loss tangent (tan δ) shows similar behavior as decreases with increase in frequency and increase with increases in Cu substituti

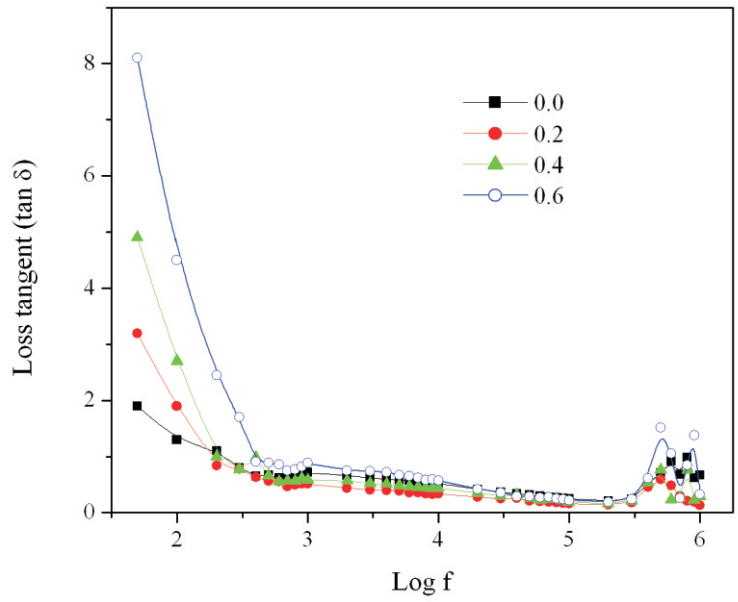

Fig. 4: Variation of loss tangent (tan δ) with applied frequency (Log f) for nanocrystalline $Ni_{0.8-x}Cu_xZn_{0.2}Fe_2O_4$ (x = 0.0 – 0.6 with steps of 0.2) ferrite

4.CONCLUSIONS

Nanocrystalline $Ni_{0.8-x}Cu_xZn_{0.2}Fe_2O_4$ (x = 0.0 – 0.6 with steps of 0.2) ferrites were synthesized by using sol-gel auo-combustion technique. The dielectric constant and dielectric loss tangent decreased with increase in frequency. The low dielectric behaviour makes ferrite materials useful in high frequency applications.

REFERENCES

[1]S. Yan, J. Geng, L. Yin, and E. Zhou, J. *Magn. Magn. Mater., 277, (2004) 84*
[2]Z. Yue, Ji. Zhou, Z. Gui, and L. Li, J. Magn. *Magn. Mater., 264, (2003) 258*
[3]W.C. Kim, S.J. Kim, S.W. Lee, and C.S. Kim, J. Magn. *Magn.Mater., 226–230, (2001) 1418*
[4] J.Y. Hsu, W.S. Ko, H.D. Shen, and C.J. Chen, *IEEE Trans. Magn.,30, (1994) 4875*
[5]Z. Yue, L. Li, J. Zhou, H. Zhang, Z. Ma, Z. Gui, *Mater.Lett.44 (2000) 279*
[6]H. I. Hsiang, W. C. Liao, Y. J. Wang, Y. F. Cheng, J. Eur. *Ceram. Soc. 24 (2004) 2015*
[7]H.M. Sung, C.J. Chen, W.S. Ko, *H.C. Lin, IEEE Trans. Magn.30 (1994) 4906*
[8]Maheshkumar L. Mane, V.N. Dhage, K. Ranganathan, *S.M. Oak, K.M. Jadhav,Radiat. Eff. Def. Solids 166 (2011) 435*