ScienceDirect

Ceramics International

Volume 44, Issue 5, 1 April 2018, Pages 5466-5472

Rietveld refinement, morphology and superparamagnetism of nanocrystalline $Ni_{0.70-x}Cu_xZn_{0.30}Fe_2O_4$ spinel ferrite

Ashok V. Humbe, Jitendra S. Kounsalye, Mahendra V. Shisode, K.M. Jadhav

Show more

https://doi.org/10.1016/j.ceramint.2017.12.180

Get rights and content

Abstract

The crystallographic phase and particle size of Cu^{2+} substituted Ni-Zn spinel ferrite prepared by nitrate-citrate route was evaluated using XRD and TEM techniques respectively. Rietveld refined XRD patterns revealed the cubic spinel phase with *Fd*-3*m* space group. The average particle size estimated from TEM image revealed the nanocrystalline nature which matches well with the crystallite size determined by XRD data. High resolution TEM exhibited the lattice fringe patterns which correspond to cubic spinel structure. The samples were characterized by M-H plots and Mossbauer spectra at room temperature. Magnetization curves exhibited typical superparamagnetic nature of samples which is in good agreement with that of Mossbauer measurements. The obtained coercive field is low which may make these materials suitable for soft magnetic device applications.

Introduction

The magnetic nanoparticles of ferrite are well known for their various applications such as gas sensors, antenna rod, radar absorbing material (RAM), suppression of EMI, high frequency transformers, targeted drug delivery and hyperthermia [1], [2], [3], [4], [5], [6], [7]. Among spinel

ferrites, NiCuZn ferrites have been rapidly developed for electronic applications like multilayer chip inductors (MLCI), circulators, phase shifters, gyrators etc. In these mixed spinel ferrites, studies of variation in Cu^{2+} or Ni^{2+} cations can be useful for elucidating the role of Cu^{2+} ions. The properties such as structural, electrical, dielectric, thermoelectric power, magnetic and Mossbauer are strongly dependent on the cation distribution of ions over tetrahedral (A) and octahedral [B] sites. In the literature, studies on copper substituted NiCuZn ferrite carried by several researchers [8], [9], [10], [11] show the improvement in permeability, DC resistivity and saturation magnetization properties. Investigations of unusual properties of nanosized ferrites by vibrating sample magnetometer provides insights about domain behavior, superparamagnetism, saturation magnetization, cation distribution, spin glass behavior and Curie temperature. Thus, understanding and controlling these parameters is important for their fine tuning of magnetic properties for many potential applications. Mossbauer spectroscopy is a very powerful tool to probe the local environment of the iron nuclei.

In the present paper, focus has been given on the effect of Cu^{2+} substitution for Ni^{2+} ions with constant concentration of Zn^{2+} on structural, magnetic and Mossbauer properties of $Ni_{0.70-x}Cu_xZn_{0.30}Fe_2O_4$ (x = 0.00, 0.10 and 0.20). The Rietveld analysis was done to check the phase purity and to determine the structural parameters. The magnetic properties were investigated by VSM and Mossbauer spectroscopy technique and the results are presented in this work.

Section snippets

Experimental

Nanoparticles of $Ni_{0.70-x}Cu_xZn_{0.30}Fe_2O_4$ (x = 0.00, 0.10 and 0.20) were prepared by citrate nitrate route using metal nitrates as oxidants and citric acid as fuel. The detailed description of synthesis processing is as reported in our earlier reports [12], [13]. As-prepared ferrite powder was annealed at 600 °C for 6 h and used for further characterizations. Rietveld refinement of XRD patterns was performed by considering Pseudo-Voigt function. Magnetization at 300 K as well as at low temperature…

Rietveld refinement

Rietveld refined XRD patterns of $Ni_{0.70-x}Cu_xZn_{0.30}Fe_2O_4$ (x = 0.00, 0.10 and 0.20) are presented in Fig. 1. The formation of single phase cubic spinel structure similar to that of JCPDS#22-1119 with space group *Fd*-3*m* was revealed by XRD patterns. The characteristic diffraction peaks of cubic structure as well as the crystal structure, both are maintained throughout copper substitution without any noticeable impurity peak. The analysis of XRD patterns reveal the nanocrystalline nature of the…

Conclusion

From the experimental results following conclusions can be drawn:

- X-Ray analysis confirmed the formation of single phase cubic spinel structure.…
- Nanocrystalline nature was confirmed through the TEM analysis.…
- M-H plot and Mossbauer spectra exhibits superparamagnetic nature.…

…

Acknowledgment

One of the authors (AVH) is thankful to Tata Institute of Fundamental Research (TIFR), Mumbai for XRD facility and SAIF, IIT Powai, Mumbai for HR-TEM measurements. Moreover, he is grateful to UGC DAE CSR, Indore for M-H and Mossbauer measurements.…

Recommended articles

References (23)

H. Jia *et al.*
Monodomain MgCuZn ferrite with equivalent permeability and permittivity for broad frequency band applications
Ceram. Int. (2017)

S.E. Jacobo *et al.*
Structural and electromagnetic properties of yttrium-substituted Ni–Zn ferrites
Ceram. Int. (2016)

Y. Cao *et al.*
Simple solid-state chemical synthesis and gas-sensing properties of spinel ferrite materials with different morphologies
Ceram. Int. (2016)

M. Sundararajan *et al.*
Photocatalytic degradation of rhodamine B under visible light using nanostructured zinc doped cobalt ferrite: kinetics and mechanism
Ceram. Int. (2017)

I. Sharifi *et al.*
Ferrite-based magnetic nanofluids used in hyperthermia applications
J. Magn. Magn. Mater. (2012)

B. Sahoo *et al.*
Biocompatible mesoporous silica-coated superparamagnetic manganese ferrite nanoparticles for targeted drug delivery and MR imaging applications
J. Colloid Interface Sci. (2014)

U. Lima *et al.*
Ni–Zn nanoferrite for radar-absorbing material
J. Magn. Magn. Mater. (2008)

I. Rahman *et al.*
A study on Cu substituted chemically processed Ni–Zn–Cu ferrites
J. Magn. Magn. Mater. (2005)

T. Ahmed *et al.*
Study on the properties of the copper substituted NiZn ferrites
J. Mater. Process. Technol. (2004)

J. Shrotri *et al.*
Effect of Cu substitution on the magnetic and electrical properties of Ni–Zn ferrite synthesised by soft chemical method
Mater. Chem. Phys. (1999)

View more references

Cited by (59)

Study of microstructure, magnetic and gas sensing properties of porous Ni<inf>0.4+</inf><inf>x</inf>Zn<inf>0.6-</inf><inf>x</inf>Ce<inf>y</inf>Fe<inf>2-</inf><inf>y</inf>O<inf>4</inf> magnetic nanoparticles
2024, Journal of Molecular Structure

Show abstract

Approaching the minimum lattice thermal conductivity in TiCoSb half-Heusler alloys by intensified point-defect phonon scattering
2023, Materials Advances

Show abstract

Coupling of electronic transport and defect engineering substantially enhances the thermoelectric performance of p-type TiCoSb HH alloy

2023, Journal of Alloys and Compounds

Show abstract

Broadband microwave magnetic and dielectric properties of (Mg<inf>0</inf><inf>·</inf><inf>6</inf>Cd<inf>0</inf><inf>·</inf><inf>4</inf>Co<inf>0</inf><inf>·</inf><inf>05</inf>Fe<inf>1</inf><inf>·</inf><inf>95</inf>O<inf>4</inf>)<inf>1-x</inf>+(MgTi<inf>2</inf>O<inf>4</inf>)<inf>x</inf> with x contents of 0.00, 0.06, 0.12, and 0.18 composites with low loss for high-frequency antennae

2023, Journal of Materials Research and Technology

Show abstract

Ba substituted SrFe<inf>2</inf>O<inf>4</inf> (SrBa<inf>0.3</inf>Fe<inf>1.7</inf>O<inf>4</inf>) for the removal of fluoride ions (F^{−1}) from the drinking water

2023, Materials Chemistry and Physics

Show abstract

Study of structural, optical, photocatalytic, electromagnetic, and biological properties Co<inf>0.75</inf>Mg<inf>0.25</inf>Ce<inf>x</inf>Fe<inf>2−x</inf>O<inf>4</inf> of Mg-Co nano ferrites

2022, Inorganic Chemistry Communications

Show abstract

View all citing articles on Scopus

View full text