Preparation of Ni-Zn Substituted on Barium and Cobalt Ferrites

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Abstract:

A series of polycrystalline mixed ferrites having chemical composition, $BaSr_2Ni_{x/2}Zn_xFe_{16-x}O_{27}$ with x changing from 0 to 0. 5 & $CoSr_2Ni_{x/2}Zn_x Fe_{16-x}O_{27}$ with x changing from 0 to 1 was prepared by chemical co-precipitation technique [15]. The efficiency of the method was refined by lowering the reaction temperature and shortening the required reaction time, due to which crystallinity improved and the value of saturated magnetization increased as well. Good quality crystals have been grown using this simple technique. To form the product, nickel and zinc ions must be assembled to develop the spinel structure in barium and cobalt ferrite. It is conjectured from the morphology of the grown crystals that this simple technique can be employed to grow ferrites and higher sintering temperature and longer sintering time contribute to grain growth.

Keywords: Barium Ferrites, Cobalt Ferrites, co precipitation, growth of ferrites

1. Introduction

Ferrite materials are insulating magnetic oxides. Unlike most materials, they possess both high permeability and moderate permittivity at frequencies from dc to the millimeter. Due to their low eddy current losses, there exist no other materials with such wide ranging value to electronic applications in terms of power generation, conditioning, and conversion.

With the development of electronic technology, composite materials have been widely used for electronic devices where higher densities, limited space and

multifunction are required. Recently the ferroelectric, ferromagnetic composite material were intensively researched for two uses, the magnetic electric sensors in radio electronics, optoelectronics, microwave electronics and transducers and compact electrical filters for suppressing electromagnetic interference (EMI).

Today ceramic magnetic materials, capable of combining a high resistivity and a high permeability, are found in numerous products used in our everyday life such as home appliances, electronic devices, communication equipments and computers [1]. Ferrimagnetic materials can have one of three main structures; spinel, garnet, and hexagonal [2]. For the hexagonal structure, there are six possible different types designated M, W, Y, Z, X, and U. the W-type hexagonal ferrites Ba Me_2 Fe_{16} O_{27}, (where Me stands for any divalent element), have a crystalline structure. Ferromagnetism is very important in industry and modern technology, and is the basis for many electrical and electromechanical devices such as electromagnets, electric motors, generators, transformers, and magnetic storage such as tape recorders and hard disks.

With the rapid development of electric technology towards higher frequencies, there is an increasing demand for various chip components and hyper-frequency devices. Multi-Layer Chip Inductors (MLCI) are among the three most important passive components and some have attracted a lot of attention because of their application in anti-electromagnetic interference. Traditional materials for making MLCI, such as the NiCuZn ferrite, cannot be used in hyper-frequency ranges, since the cut-off frequency is limited below 100 MHz by their spinel structure. On the other hand, hexagonal ferrites have a much higher cut-off frequency than spinel ferrites, owing to their planar magneto-crystalline anisotropy. Hexagonal ferrites constitute a large class of ferromagnetic oxides that were first synthesized in 1950s, at the Philips Laboratories [3]. Extensive investigations have been carried out on the synthesis and properties of barium ferrite. Polycrystalline hexaferrites, in particular, are very useful for microwave applications due to their very low dielectric loss. Hexagonal ferrites are divided into six different types: M ($AFe_{12}O_{19}$), W (AM $Fe_{16}O$), X (A Me Fe O), Y (A $_2$ Me $Fe_{12}O$), U (A Me Fe $_{36}$ O), Z (A $_3$Me Fe O_{41}), where A = Ba, Sr, La and M = a divalent transition metal [4, 5].

These compounds are prepared by using various synthesis routes such as chemical co-precipitation [6, 7], low–temperature combustion [8], sol-gel [9], mechanical alloying [10, 11], mechanical activation [12], solid-state reaction [13] and microemulsion and reverse microemulsion [14].

2. Experimental procedure

All the samples were prepared by the chemical co-precipitation technique. A series of polycrystalline mixed ferrites having chemical composition, $BaSr_2Ni_{x/2}Zn_xFe_{16-x}O_{27}$ with x changing from 0 to 0. 5 & $CoSr_2Ni_{x/2}Zn_x Fe_{16-x}O_{27}$ with x changing from 0 to 1 was prepared by chemical co-precipitation technique [15]. The A. R grade nitrates were used as starting material. Stoichiometric amount of barium nitrate, zinc nitrate, strontium nitrate, ferric nitrate, nickel nitrate (99. 99 %) etc. (given in tables below) were dissolved one by one in 100 ml of de-ionized water. Ammonia solution (30%)

was then added slowly in the mixture to adjust $_pH$ of 8. The mixed solution were stirred for two hours and kept at room temperature for 24 hours for aging. The barium and cobalt hexaferrites precipitates shall be separated in a centrifuge machine at 2500 rpm for 20 minute. The prepared precipitate was then washed in 1 : 1 mixture of methanol and acetone followed by 100 % de-ionized water to remove impurities. The precipitate was then kept for drying at 100 ^{0}C for 24 hours. The efficiency of the method was refined by lowering the reaction temperature and shortening the required reaction time. Finally it was calcinated at 1000^{0}C for 4 hours to obtain $BaSr_2$ $(Ni_{x/2}Zn_x)$ $Fe_{16-x}O_{27}$ [16]. Thus, following the chemical co-precipitation technique Ni-Zn substituted on Barium and Cobalt Ferrites crystals can be grown. Stichometric ratios of compounds used for sample preparation are as given below:

Preparation of $CoSr_2$ $(Ni_{x/2}Zn_x)$ $Fe_{16-x}O_{27}$

Table 1

Compound	Actual Weight taken	Molecular weight
$CO(NO_3)_2 \cdot 6H_2O$	1. 2162	291. 04
$2[Sr(NO_3)_2]$	1. 7688	423. 26
$16[Fe(NO_3)_3 \cdot 9H_2O]$	27. 0147	6464

Table 2.

Compound	Actual Weight taken	Molecular weight
$CO(NO_3)_2 \cdot 6H_2O$	1. 2	291. 04
$2[Sr(NO_3)_2]$	1. 7454	423. 26
$0. 2[Ni(NO_3)_2 \cdot 6H_2O]$	0. 23985	58. 162
$0. 4[Zn(NO_3)_2 \cdot 6H_2O]$	0. 4905	118. 988
$15. 8[Fe(NO_3)_3 \cdot 9H_2O]$	26. 3235	6383. 2

Table 3.

Compound	Actual Weight taken	Molecular weight
$CO(NO_3)_2 \cdot 6H_2O$	1. 1854	291. 04
$2[Sr(NO_3)_2]$	1. 7226	423. 26
$0. 4[Ni(NO_3)_2 \cdot 6H_2O]$	0. 4734	116. 324
$0. 8[Zn(NO_3)_2 \cdot 6H_2O]$	0. 9684	237. 976
$15. 6[Fe(NO_3)_3 \cdot 9H_2O]$	25. 6506	6302. 4

Table 4.

Compound	Actual Weight taken	Molecular weight
$CO (NO_3)_2. 6H_2O$	1. 1691	291. 04
$2 [Sr (NO_3)_2]$	1. 7004	423. 26
$0. 6 [Ni (NO_3)_2. 6H_2O]$	0. 7008	174. 486
$1. 2 [Zn (NO_3)_2. 6H_2O]$	1. 434	356. 964
$15. 4 [Fe (NO_3)_3. 9H_2O]$	24. 9951	6221. 6

Table 5.

Compound	Actual Weight taken	Molecular weight
$CO (NO_3)_2. 6H_2O$	1. 1541	291. 04
$2 [Sr (NO_3)_2]$	1. 6785	423. 26
$0. 8 [Ni (NO_3)_2. 6H_2O]$	0. 9225	232. 648
$1. 6 [Zn (NO_3)_2. 6H_2O]$	1. 8876	475. 952
$15. 2 [Fe (NO_3)_3. 9H_2O]$	24. 3561	6140. 8

Table 6.

Compound	Actual Weight taken	Molecular weight
$CO (NO_3)_2. 6H_2O$	1. 1397	291. 04
$2 [Sr (NO_3)_2]$	1. 6575	423. 26
$[Ni (NO_3)_2. 6H_2O]$	1. 1388	290. 81
$2 [Zn (NO_3)_2. 6H_2O]$	2. 3298	594. 94
$15 [Fe (NO_3)_3. 9H_2O]$	23. 733	6060

Preparation of $BaSr_2 (Ni_{x/2}Zn_x) Fe_{16-x}O_{27}$

Table 1

Compound	Actual Weight taken	Molecular weight
$Ba (NO_3)_2$	1. 0965	261. 35
$2 [Sr (NO_3)_2]$	1. 776	423. 26
$16 [Fe (NO_3)_3. 9H_2O]$	27. 1269	6464

Table 2.

Compound	Actual Weight taken	Molecular weight
Ba $(NO_3)_2$	1. 0893	261. 35
2 [Sr $(NO_3)_2$]	1. 7643	423. 26
0. 1 [Ni $(NO_3)_2$. $6H_2O$]	0. 12122	29. 081
0. 2 [Zn $(NO_3)_2$. $6H_2O$]	0. 24800	59. 494
15. 9 [Fe $(NO_3)_3$. $9H_2O$]	26. 7768	6423. 6

Table 3.

Compound	Actual Weight taken	Molecular weight
Ba $(NO_3)_2$	1. 0821	261. 35
2 [Sr $(NO_3)_2$]	1. 7526	423. 26
0. 2 [Ni $(NO_3)_2$. $6H_2O$]	0. 24083	58. 162
0. 4 [Zn $(NO_3)_2$. $6H_2O$]	0. 4926	118. 988
15. 8 [Fe $(NO_3)_3$. $9H_2O$]	26. 4315	6383. 2

Table 4

Compound	Actual Weight taken	Molecular weight
Ba $(NO_3)_2$	1. 0749	261. 35
2 [Sr $(NO_3)_2$]	1. 7409	423. 26
0. 3 [Ni $(NO_3)_2$. $6H_2O$]	0. 3588	87. 243
0. 6 [Zn $(NO_3)_2$. $6H_2O$]	0. 7341	178. 482
15. 7 [Fe $(NO_3)_3$. $9H_2O$]	26. 0907	6342. 8

Table 5

Compound	Actual Weight taken	Molecular weight
Ba $(NO_3)_2$	1. 0677	261. 35
2 [Sr $(NO_3)_2$]	1. 7295	423. 26
0. 4 [Ni $(NO_3)_2$. $6H_2O$]	0. 4752	116. 324
0. 8 [Zn $(NO_3)_2$. $6H_2O$]	0. 9723	237. 976
15. 6 [Fe $(NO_3)_3$. $9H_2O$]	25. 7544	6302. 4

Table 6

Compound	Actual Weight taken	Molecular weight
Ba $(NO_3)_2$	1. 0608	261. 35
2 [Sr $(NO_3)_2$]	1. 7181	423. 26
0. 5 [Ni $(NO_3)_2$. $6H_2O$]	0. 5901	145. 405
[Zn $(NO_3)_2$. $6H_2O$]	1. 2075	297. 47
15. 5 [Fe $(NO_3)_3$. $9H_2O$]	25. 4226	6262

Result:

A series of polycrystalline mixed ferrites having chemical composition, $BaSr_2Ni_{x/2}Zn_xFe_{16-x}O_{27}$ with x changing from 0 to 0. 5 & $CoSr_2Ni_{x/2}Zn_x Fe_{16-x}O_{27}$ with x changing from 0 to 1 was prepared by chemical co-precipitation technique [15]. The efficiency of the method was refined by lowering the reaction temperature and shortening the required reaction time, due to which crystallinity improved and the value of saturated magnetization increased as well. Good quality crystals have been grown using this simple technique. To form the product, nickel and zinc ions must be assembled to develop the spinel structure in barium and cobalt ferrite. It is conjectured from the morphology of the grown crystals that this simple technique can be employed to grow ferrites and higher sintering temperature and longer sintering time contribute to grain growth.

References

[1]   B. Viswanathan and V. R. K. Murthy, Ferrite Materials: Science and Technology (Narosa publishing house, New Delhi, 1990), p. 429.

[2]   W. H. Von Aulock and A. H. Bobeck, Ferrimagnestism: The Encyclopedia of Physics, third edition, Robert M. Besancon, Van Nostrand Reinold, New York, 1990), p. 429.

[3]   Y. Mizuno, S. Taruta, K. Kitajima, J. Mater. Sci. 40, 165 (2005).

[4]   D. M. Hemeda, O. M. Hemeda, J. Magn. Magn. Mater. 320, 1557 (2008).

[5]   M. El-Saadawy, Mater. Lett. 39, 149 (1999).

[6]   P. Shepherd, K. K. Mallick, R, J. Green, J. Magn. Magn. Mater 311, 683 (2007).

[7]   T. Ogasawara, M. A. S. Oliveria, J. Magn. Magn. Matter. 217, 147 (2000).

[8]   J. Huang, H. Zhuang, W. Li, J. Magn. Magn. Mater. 256 (2003) 390.

[9]   R. M. Garcica, E. R. Ruiz, E. E. Rams, R. M. Sanchaz, J. Magn. Magn. Mater 223, 133 (2001).

[10] J. Ding, D. Maurice, W. F. Miao, P. G. McCormick, R, Street, J. Magn. Magn. Matter. 150, 417 (1995).

[11] G. Mendoza-Suarez, J. A. Malutes-Aquino, J. I. Escalante-Garcia, H. Mancha-Molinar D. Rios-Jara, K. K. Johal, J. Magn. Magn. Mater. 223, 55 (2001).

[12] J. Subrt, J. Tlaskal, Sol. Sta. Io. 63-65, 110 (1993).

[13] Ali Ghasemi, Akimitsu Morisako, J. Alloy. Compd 456, 485 (2008).

[14] A. Kosak, D. Makovec, M. Drofenik, Phys. State. Sol. Cl (12). 3521 (2004).

[15] R. B. Jotania, R. B. Khomane, A. S. Deshpande, C. C. Chauhan, B. D. Kulkarni, J. Sci. Res. I (1), 1-13 (2009).

[16] L. Balamuth, Phys, Rev. 45, 715, (1935).