Preparation and structural Properties of Nanohexa Ferrite Doped with Lanthanum Rare Earth Ions

R. M. Kershi and Samir Osman Al- Asbahi

***Abstract*-** This work is an attempt to describe the fine structure of nanocrystalline Barium W-type hexagonal ferrites doped with lanthanum rare earth ions which have been prepared using the ceramic technique. The X-ray powder diffraction was employed to investigate their microstructure parameters. The X-ray data were analyzed using CHEKCELL program in order to refine the unit cell parameters, PEAKFIT software to identify and refining the peak positions. The Williamson-Hall method was used to determine the crystallite size and lattice strain. The results have been discussed to elucidate the effect of La doping on all the lattice parameters.

***Keywords*—**Preparation, structural Properties, Nanohexa Ferrite, Doped, Lanthanum Rare Earth Ions

I. INTRODUCTION

BARIUM hexagonal ferrites have been widely used in magnetic recording, permanent magnets, microwave devices and electromagnetic shielding fields due to their high saturation magnetization, great coercivity, excellent chemical stability and corrosion resistance [1–4]. They are suitable candidates for high-density, overcoat- free, contact or semi-contact recording media due to large magneto-crystalline anisotropy and strong dependence of the orientation of easy axis on the microstructure [5–8]. W-type hexagonal ferrites have potential application as permanent magnets for electrical, electronic and automobile devices [9]. Also, W- hexagonal ferrites with planar structure are among the most popular microwave absorption materials for their higher efficiency and lower cost than those of other materials [10]. The structural and magnetic properties of W-type hexagonal ferrite depend on many factors like method of preparation, sintering temperature and type and amount of substitution [11–15]. Rare earth (RE) ions have typical relaxation characteristics and contribute to the improve of the properties of hexagonal ferrites [16].

Influence of different RE substitution on the microstructure of Ba-W type hexagonal ferrites were studied by Jing *et al.* and M.A. Ahmed *et al.* [17, 18]. Also preparation and properties of Ba-W type diluted with La ions were analyzed by M. A. Ahmed *et al.* [19]. In this paper, we focus on the structural properties of nanocrystalline BaLa-W type hexagonal ferrites.

R. M. Kershi and Samir Osman Al- Asbahi are with Physics Department, Faculty of Science, Ibb University, Ibb, Yemen

II. EXPERIMENTAL METHOD AND DEVICES

Series of nanocrystalline hexagonal ferrite ($Ba_{1-z}La_zW$ type where z = 0, 0.01, 0.02,0.03 and 0.04) were prepared by the ceramic technique at presintering 900 ^{0}C and final sintering 1300 ^{0}C from barium carbonate and (lanthanum, cobalt, magnesium, and zinc) oxides as raw materials. The synthesis steps detail as described in previous publications [1, 20]. The X-ray powder diffraction patterns were obtained using Scintag X-ray diffractometer (λ=1.5418 Å). The recorded data of X-ray diffraction lines were performed by step scanning method in 2θ in the range 20.08^o – 79.92^o in steps of 0.16^o. The phases, the lattice constants and the physical structures of the hexagonal ferrite powders were calculated from X-ray diffractograms. CHEKCELL program and PEAKFIT software were used to refine the unit cell parameters, and to identify and refine the peaks positions respectively. Williamson-Hall method was used to determine the crystallite size and lattice strain.

III. RESULT AND DISCUSSION

Fig.1 show the XRD patterns of the investigated samples where, one can be observed that the intensity of a secondary phase increases with the **increasing of La content (z). X-ray diffraction pat**terns of the samples with z = 0 and z = 0.01 indicate single, W-hexagonal ferrites, phase is obtained. For the samples with z $\geq$ 0.02 $LaFeO_3$ orthoferrite, the secondary phase is observed. The relative intensities of the $LaFeO_3$ peaks increase with increased La ions content where the La ions did not substitute totally into the structure of hexagonal ferrite.

Fig.2 illustrates volume of unit cell of the investigated samples versus La content (z). This figure shows that the volume of unit cell is decreasing with increased La content (z) . This character may come from the values of (a) and (c) lattice parameters.

The lattice parameters of the investigated samples have been refined using CHEKCELL PROGRAM and are given in Table1.

From the table (1) one can see that the lattice parameter (a) slightly increases whereas the parameter (c) decreases with increased La ions.

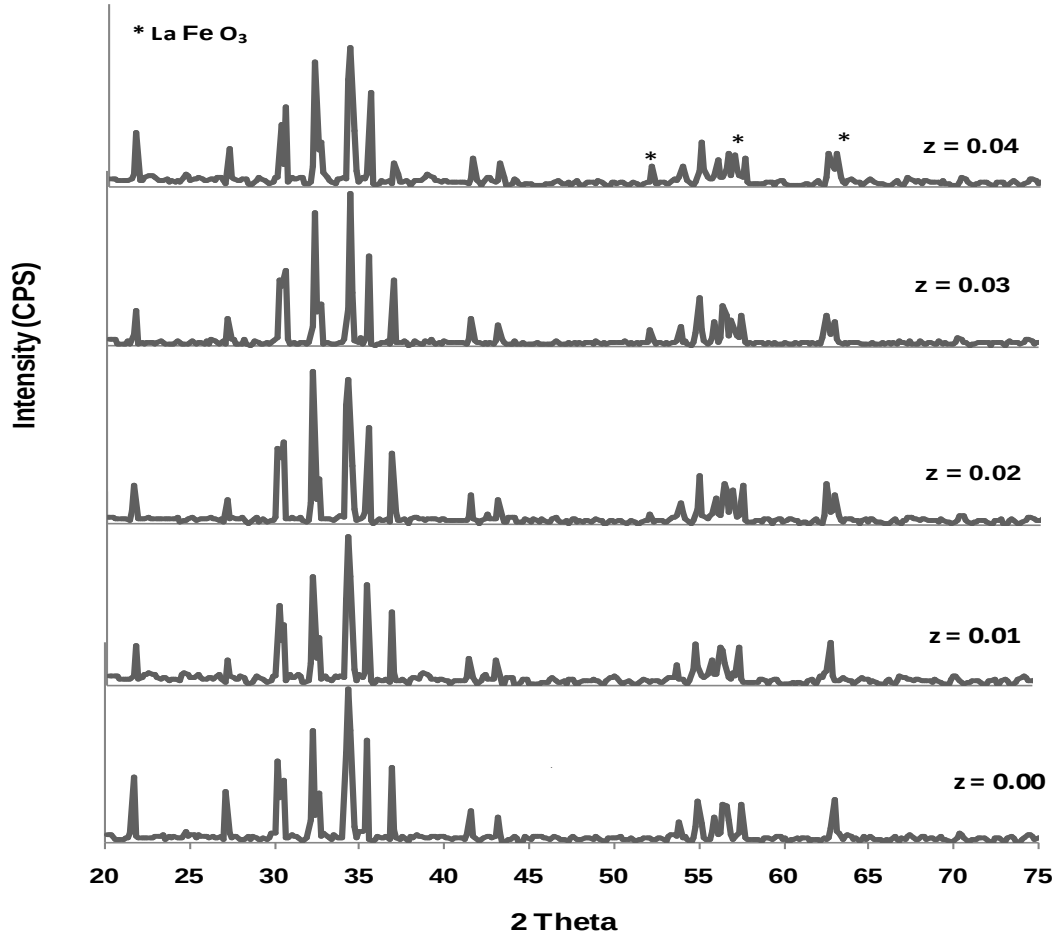

Fig 1. XRD paterns of the investigated samples.

This is due to the replacement of Ba^{2+} ions (radius 1.35 A) in the hexagonal block R by La^{3+} (radius 1.15A) which means that the distance between c axis layers decreases with increased La ions content. In contrast some Fe^{3+} ions (radius 0.64 A) will be change to Fe^{2+} ions (radius 0.76 A) in order to balance the charge of the system. Hence the substitute in of Ba^{2+} ions by La^{3+} ions leads to changing some Fe^{3+} ions of both 12k in octahedral sites and 2b of pyramidal sites to Fe $^{2+}$ ions [25], this may lead to increases the a lattice parameter. But the effect of (c) parameter is higher than that of (a) parameter, hence the volume of unit cell is decreases with increased La ions content. By using PEAKFIT program, we have observed around 30 reflections. We have used only permanent reflections for our analysis. The width at half maximum was determined for every reflection in all samples. The R^2 values for obtained widths approach from unity (≈0.99) which reflects the accuracy of the values. Then the equation of Williamson-Hall has been applied to compute the average of crystallite size and the average lattice strain of the samples from the plot. We have drawn Williamson-Hall plot for all the investigated samples.

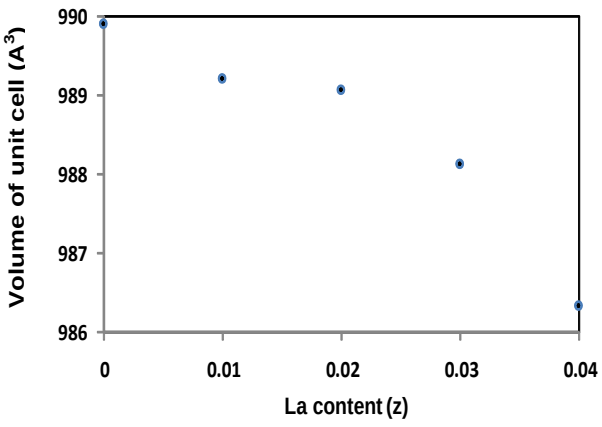

Fig 2. Volume of unit cell Vs La content (z).

TABLE1

LATICE PARAMETERS FOR THE SAMPLES

La ions content (z)	a (A^o)	c (A^o)
0	5.912	32.686
0.01	5.912	32.798
0.02	5.916	32.5178
0.03	5.926	32.5919
0.04	5.917	32.77

Fig.3 shows the variation of average crystallite size with La content (z). It is illustrate that the crystallite size decreases with increased La ions. This may be attributed to the fact that the existence of La ions impeded crystal growth, due to the La ions partially entered the hexagonal structure.

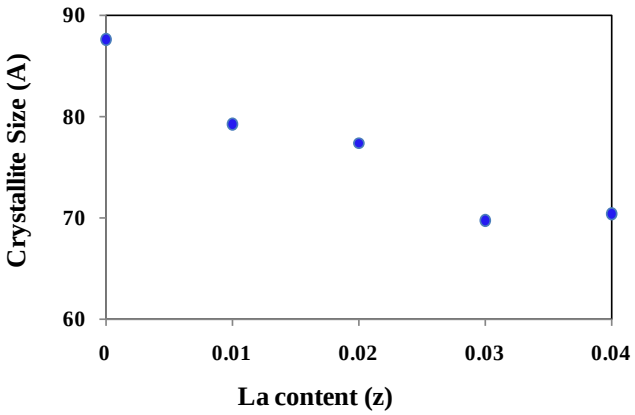

Fig.3 The average of crystallite size Vs La content (z).

Fig.4 explains the effect of doping the samples with La ions on the average lattice strain. From this figure we find that the lattice strain of z = 0 sample (i.e. without La rare earth ions) have the highest value. Then suddenly the value of the strain go to the lowest value for z = 0.01 sample. After that the value of lattice strain is increasing with increased La ions. This relationship between the lattice strain and La content (z) can be illustrated as follow; the highest value of z = 0 may be returned to some defects (such as vacancies and imbalance in the distribution of some ions at their sites in the structure) induced through the growth of the sample. The lowest value of lattice strain of z = 0.01 is coming because the substitute of Ba ions by La ions leads to negative microstrain of R hexagonal block and in the same time positive microstrain will be happened in S cubic block by changing some Fe^{3+} to Fe^{2+}. For the samples with $z \geq 0.02$ the secondary phase is increasing with increased of La ions as showed in Fig.1. This leads to increasing the values of lattice strain.

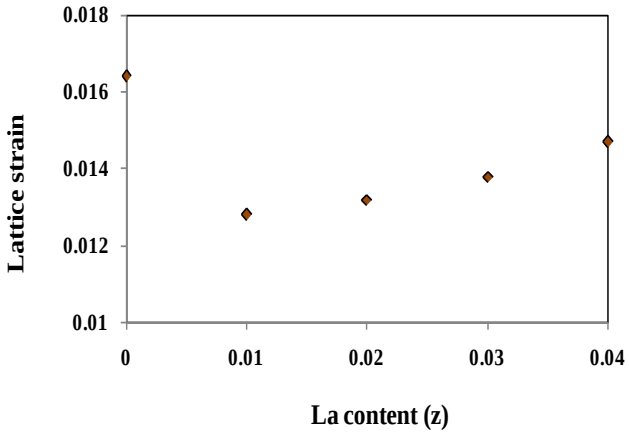

Fig.4 The average of lattice strain Vs La content (z).

IV. CONCLUSION

We have carried out X-ray powder diffraction for the Barium W-type hexagonal ferrites doped with lanthanum rare earth ions using solid state reaction technique. The main structural parameters of the samples such as cell parameters, crystallite size and lattice strain were investigated. Different programs have been utilized to obtain more accurate data. Doping with La caused fractional changes in cell parameters. We have attempted roughly to get linear relationship between average crystallite size and average lattice strain with La content. From that it is noted the variation of crystallite size and lattice strain with La content varies. Here the lattice strain dose not represent one kind of lattice strain but it is mainly caused by site defect due to the size and a mount of the rare earth doped ions.

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