

Magnetic Properties of Nano-Crystalline Barium Ferrite Synthesized by Different Synthesis Route

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We have synthesized $\text{Ba}_{1-x}\text{La}_x\text{Fe}_{12}\text{O}_{19}$ ($0 \leq x \leq 0.4$) and $\text{BaFe}_{12-y}\text{Nd}_y\text{O}_{19}$ ($0 \leq y \leq 4$) samples in ammonium nitrate melt and nitric acid. The effects of La and Nd doping on the microstructure and magnetic properties of $\text{BaFe}_{12}\text{O}_{19}$ were investigated. The highest coercive field was obtained for the sample having La content, $x = 0.3$.

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1. Introduction

The barium ferrite has attracted great interest in the magnetic material field and has been widely used as a permanent magnet because of its fairly large magneto-crystalline anisotropy and high Curie temperature, together with relatively large saturation magnetization, excellent chemical stability and corrosion resistivity. Various chemical routes were used to synthesize nanoparticles of Ba-hexaferrite: microemulsion [1], chemical co-precipitation [2], glass crystallization [3], combustion, sol-gel synthesis [4], hydrothermal synthesis [5], oxidation in nitric acid method [6], and ammonium nitrate melt (ANM) technique [7]. The magnetic properties of $\text{BaFe}_{12}\text{O}_{19}$ can be improved by the substitution of Ba^{2+} and/or Fe^{3+} . In order to achieve this purpose, element substitution was widely used for the synthesis of magnetic materials with appropriate saturation magnetization and coercivity [8–13].

In this work, we aimed to synthesize single domain La and Nd doped barium ferrite nanoparticles with high saturation magnetization (M_s) and high coercivity (H_c) by the ANM and oxidation in nitric acid method.

2. Experimental

Appropriate amounts of BaCO_3 , Fe_2O_3 , Nd_2O_3 and La_2O_3 powders of high purity (99%) were weighed and mixed at different La and Nd. The mixed powder was put into the melted ammonium nitrate or nitric acid. The solution was mixed on a hot plate with magnetic stirrer until the liquid disappeared. Before grinding in an agate mortar for 15 min, small amount of isopropyl alcohol was added to make wet grinding. The precursor was calcinated at 450°C for 5 h to remove possible organic compounds. Then, the precursor was again grinded for

15 min with isopropyl alcohol and dried, pelletized under the pressure of 200 MPa. The pressed disc-shaped pellets (diameter 16 mm, thickness 3 mm) were sintered at 1000°C for 2 h in the air and then cooled in the furnace.

Structural analysis was done by scanning electron microscope (JEOL 6335F, Field Emission Gun). The magnetic properties of samples were examined at room temperature using vibrating sample magnetometer (LDJ Electronics Inc., Model 9600) with the maximum field up to 1.6 T.

3. Results and discussion

Figure 1a,b shows the scanning electron microscopy (SEM) micrographs of the pure and La-doped samples calcinated at 1000°C for 2 h. It is clearly seen that the samples, Fig. 1a and b, have grains between 100 nm and 250 nm, in the single domain limit ($< 1 \mu\text{m}$). Besides, the grains are distributed homogeneously without massive agglomerations.

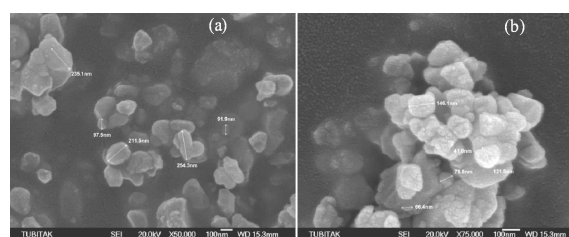


Fig. 1. SEM micrographs of the samples: (a) pure, (b) La amount of $x = 0.3$.

The hysteresis loops of Nd-substituted barium hexaferrites sintered at 1000°C show a behavior of the hard magnetic materials with high coercive field, as shown in Fig. 2. As seen from the figure, the M_s values decrease upon increasing Nd content, whereas the H_c values remain almost the same with Nd doping for

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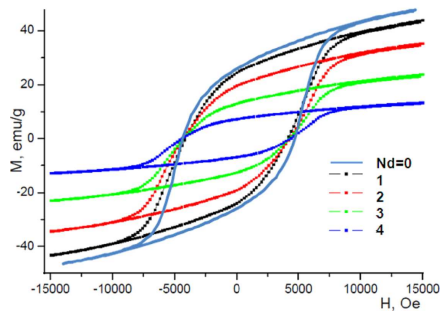


Fig. 2. The hysteresis loops of $\text{BaFe}_{12-y}\text{Nd}_y\text{O}_{19}$ ($0 \leq y \leq 4$) samples.

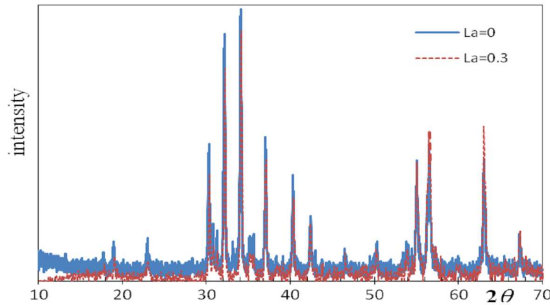


Fig. 3. XRD patterns of the $\text{La} = 0.0$ and $\text{La} = 0.3$ samples.

$\text{BaFe}_{12-y}\text{Nd}_y\text{O}_{19}$ ($1 \leq y \leq 4$). The X-ray diffraction patterns of $\text{Ba}_{1-x}\text{La}_x\text{Fe}_{12}\text{O}_{19}$ ($x = 0.0$ and $x = 0.3$) hexaferrite powders are shown in Fig. 3. The X-ray diffraction patterns show the samples to have a single $\text{BaFe}_{12}\text{O}_{19}$ phase. This indicates that La^{3+} ions were completely solved into the hexagonal crystal lattice. The variations of $M-H$ loops of the $\text{Ba}_{1-x}\text{La}_x\text{Fe}_{12}\text{O}_{19}$ ($0 \leq x \leq 0.4$) samples are also shown in Fig. 4. The M_s decreases and there is increase in coercivity with La amount in samples. The H_c becomes maximum for doping levels $x = 0.3$ and 0.4 . However, M_s corresponding to $x = 0.3$ is slightly higher than that of the latter one. Therefore, the optimum doping level seems to be $x = 0.3$ to have the highest coercivity and high magnetization.

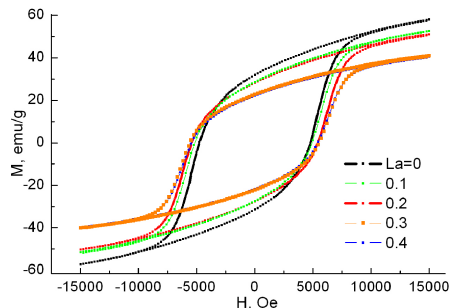


Fig. 4. The $M-H$ loops of $\text{Ba}_{1-x}\text{La}_x\text{Fe}_{12}\text{O}_{19}$ ($0 \leq x \leq 0.4$) samples.

4. Conclusion

$\text{Ba}_{1-x}\text{La}_x\text{Fe}_{12}\text{O}_{19}$ ($0.0, 0.1, 0.2, 0.3, 0.4$) and $\text{BaFe}_{12-y}\text{Nd}_y\text{O}_{19}$ ($1, 2, 3, 4$) ferrite powders were prepared and investigated. The microstructure and magnetic properties have been characterized. Comparing the La-doped barium ferrite with the undoped barium ferrite, the coercivity of the La-doped barium ferrite is higher than that of the undoped barium ferrite. However, the coercivity of Nd-doped powders was remained nearly same. When the La amount is $x = 0.3$, the coercivity of La-doped barium ferrite shows the maximum value. The saturation magnetization of the samples was found to decrease with increase in the La and Nd content. The results showed that La and Nd doping to $\text{BaFe}_{12}\text{O}_{19}$ changes the magnetic properties of this material significantly.

Acknowledgments

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