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► To cite this version:

J.-H. Lee, T.-B. Byeon, H.-J. Lee, C.-G. Kim, T.-O. Kim. Preparation of Single Crystallites of Barium Ferrite by Hydrothermal Synthesis. Journal de Physique IV Proceedings, 1997, 07 (C1), pp.C1-751-C1-752. 10.1051/jp4:19971307 . jpa-00255074

HAL Id: jpa-00255074

<https://hal.science/jpa-00255074>

Submitted on 1 Jan 1997

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Preparation of Single Crystallites of Barium Ferrite by Hydrothermal Synthesis

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Abstract : We investigated the formation process and characteristics of barium ferrite single crystallite prepared by hydrothermal synthesis and the effect of heat treatment on crystallization and magnetic properties. The single phase of barium ferrite is formed in the batch composition Ba:Fe 1:10 and above alkali molar ratio 2.5. The particle size has tendency to decrease with increase in alkali molar ratio. Crystallization and magnetic properties of the hydrothermal-synthesized barium ferrite powders can be improved by the heat treatment.

1. Introduction

Barium Ferrite is attractive not only as hard magnetic material but also for use in high frequency device materials, since it has large magnetocrystalline anisotropy with easy magnetization direction in the c-axis, high electric resistance ($\sim 10^8 \Omega \text{m}$) and chemical stability. Even though metal alloy films such as Co-Cr are also useful for perpendicular recording media, barium ferrite has received recently great attention according to the superior properties of chemical stability, mechanical strength, large scale productivity, electrical resistivity compared to metal films and utility of the conventional coating equipments [1-3]. For the fundamental research of perpendicular recording media the preparation of single crystal particles of barium ferrite by hydrothermal synthesis and their characteristics are reported in this paper.

2. Experimental procedure

The suspension was prepared by mixing $\text{Fe}(\text{NO}_3)_3$ and $\text{Ba}(\text{NO}_3)_2$ aqueous solution and NaOH solution under the condition of Fe:Ba=1:8~1:12 and alkali molar ratio $R=\text{OH}^-/\text{NO}_3^-$ 2, 2.5, 3, 4. This suspension was poured into 1000ml autoclave vessel and was hydrothermally synthesized at 332°C for 5hr. Hydrothermal-synthesized powder was heat-treated for the improvement of crystallinity. The composition, crystalline phase, particle morphology and magnetic properties of barium ferrite powder were investigated by various instruments.

3. Results and discussion

3.1 Phase identification

In the batch composition of Ba:Fe=1:8, BaCO_3 is formed owing to excess of barium and in Ba:Fe=1:12, α - Fe_2O_3 is adulterated at $R=2$ but single phase of barium ferrite is formed in the range of $R=2.5\sim 4$. By heating hydrothermal-synthesized powder at 900°C for 1hr, the peak intensity of α - Fe_2O_3 is decreased, but that of barium ferrite is relatively increased. This results confirm that crystallinity is improved by heat treatment.

3.2 Morphology

Barium ferrite having the best hexagonal plate shape is obtained at $R=2.5$. By heat-treating the hydrothermal-synthesized particle, the crystallinity and proper hexagonality are markedly improved.

Figure 1: Scanning electron micrographs of barium ferrite powder Fe/Ba=10, prepared hydrothermally at 332°C for 5hr in R=2.5.

Figure 2: Scanning electron micrographs of the heat-treated (900°C, 1hr) barium ferrite powder with Fe/Ba=10, prepared hydrothermally at 332°C for 5hr in R=2.5.

3.3 Composition distribution

Figure 3 shows composition changes of as-hydrothermal-synthesized barium ferrite powder and heat-treatment sample. In the case of as-hydrothermal-synthesized samples, an excess of barium ions exists on the surface of crystallite. The heat-treated crystallites exhibit a composition ratio closer to stoichiometric composition of barium ferrite due to diffusion of Ba^{2+} into the interior. Figure 3 shows the reduced radius of the Ba-ferrite powder by modeling. It is assumed that hexagonal platelike Ba-ferrite powder is solved to disk.

Figure 3: The composition of barium ferrite powders depending on the depth from surface (hydrothermal synthesis condition 332°C, 5hr, Fe/Ba=10)

* Ratio of radius reduction = (r/r_0) By modeling

r_0 : average radius of powder

r : average radius of powder after acid treatment

Figure 4: Saturation magnetization and coercive force of heat-treated (900°C, 1hr) barium ferrite powder depending on alkali molar ratio. (hydrothermal synthesis condition 332°C, 5hr, and Fe/Ba=10)

3.4 Magnetic properties

The saturation-magnetization of the as-hydrothermally synthesized barium ferrite powder has the presented maximum value at R=2.5, as predicted by the morphology. By heat treatment, all values of those is increase, and the maximum value appears at R=2.5, too. But, the coercive force at R=2.5 presents minimum value, and the same by heat treatment for the reason that the clusters are easily moved by the applied magnetic field due to the smooth surface.

4. Conclusion

- ① In the batch composition of Ba:Fe=1:10, the single phase of barium ferrite can be formed. Above alkali molar ratio 2.5 the particles size decreases with increment in alkali molar ratio.
- ② With increase in alkali molar ratio, coercive force and saturation magnetization of barium ferrite powder with composition Ba:Fe=1:10 increases and decreases, respectively.
- ③ Crystallographic and magnetic characteristics of hydrothermal-synthesized barium ferrite powder can be improved by the heat treatment.
- ④ Excess barium ions exist on surface of the as-hydrothermally-synthesized barium ferrite powder, and a composition near to stoichiometric is obtained by heat treatment.

5. References

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