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COBALT FERRITE NANOPARTICLES SYNTHESIZED BY A SELF-IGNITION REACTION

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Introduction

Cobalt ferrite, $CoFe_2O_4$, is unique among cubic spinel ferrites with a cubic magnetocrystalline anisotropy as high as that of hexagonal barium ferrite and has been well studied for possible magnetic recording applications. But it has seldom shown coercivities as high as barium ferrite nanoparticles. It is known to attain a uniaxial anisotropy component on magnetic annealing, only in nonstoichiometric ferrite, that is believed to be related to Co cation distribution [1]. Nanoparticles prepared by low temperature chemical methods often show magnetic properties and cation distributions different from bulk [2]. In this study, we report the direct synthesis of stoichiometric cobalt ferrite nanoparticles in the 5-20 nm size range from a citrate precursor by a self ignition reaction, and investigation of possible magnetic annealing effect on coercivity .

Experimental

The Cobalt ferrite nanoparticles were synthesized by a citrate precursor method. Aqueous solutions of cobalt and ferric nitrates in the required stoichiometric ratio were reacted with 1:1 molar ratio of citric acid under reflux after optimizing pH of the soultion by adding ammonia. When the reacted solution is evaporated slowly, the self-ignition reaction is initiated at near dryness and results in the formation of fine brown flakes of ferrite. The XRD patterns were reorded on a Siemens D5000 X-ray diffractometer with Cu Kα radiation and magnetization measurements were arried out on a VSM. The field annealing was carrid out in a magnetic field of 700 Oe.

Results and Discussion

XRD pattern of the self ignited powder shows typical inverse spinel structure with broad lines characteristic of nanoparticles as shown in Fig. 1. In TEM observations, particles in the of 5-20 nm size range could be observed at different stages of nucleation and growth, developed from the citrate complex during the self ignition reaction. Hysteresis loop of this sample shows a relatively low magnetization of 30 emu/g and a coercivity of 800 Oe. The magnetization does not saturate in 10 kOe due to the higher anisotropy field of cobalt ferrite and also due to the presence of a fraction of

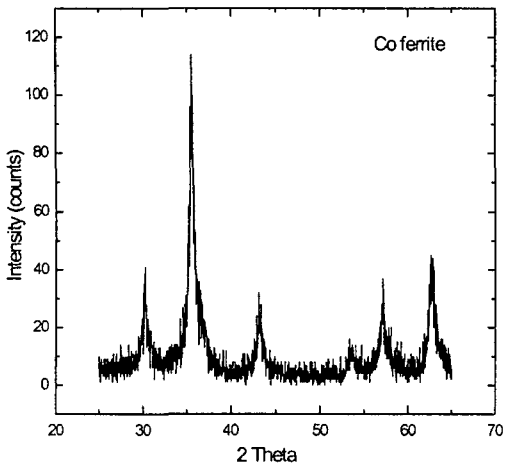

Fig. 1. XRD pattern of as-prepared sample.

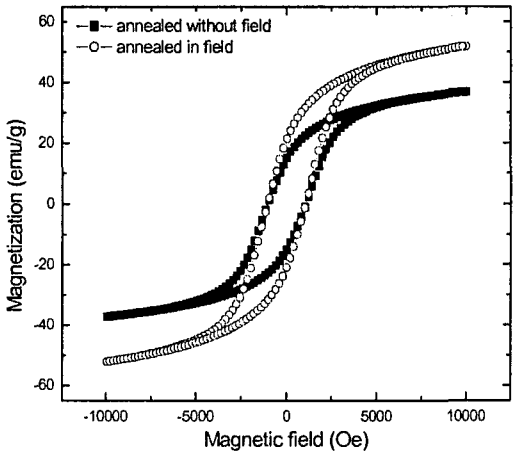

Fig. 2. M-H loops of Co-ferrite samples.

smaller superparamagnetic particles. On annealing in a magnetic field of 700 Oe at 450 °C the magnetization of the sample increases to 55 emu/g and coercivity increases to 1376 Oe. The sample annealed in the absence of magnetic field, interestingly, showed a coercivity of 1053 Oe only . Magnetic annealing induced uniaxial anisotropy has been reported in nonstoichiometric cobalt ferrites and not in stoichiometric ferrites as in the present case. Induced uniaxial anisotropy is considered to be a strong function of Co cation distribution at the octahedral sites. It is quite possible that during the fast self-ignition reaction process, the Co cations do not get an opportunity to settle into their equillibrium positions in the octahedral sublattice in the spinel structure, which they eventually do later during the field annealing process, leading to increase in coercivity. This difference in cation distribution in the self-ignited sample probably also explains its relatively low magnetization.

Conclusions

Cobalt ferrite nanoparticles in the 5-20 nm size range could be prepared by a self-ignition reaction without additional heat-treatments. The as-prepared samples show characteristic spinel structure in XRD with larger linewidth due to the nanoparticle nature. Field annealing induced anisotropy and increase in coerciviy is observed in these stoichiometric ferrite samples presumably due to the disturbed Co cation distribution in the octahedral sublattice during the fast self-ignition reaction process.

References

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