Magnetic Properties of Cobalt Ferrite Based Core-shell Nanoparticles at High Magnetic Fields

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Introduction

Cobalt ferrite ($CoFe_2O_4$) crystallizes in a partially inverse spinel structure and space group *Fd3m -O*h7 with general formula $(Co_{1-\delta}Fe_{\delta})[Co_{\delta}Fe_{2-\delta}]O_4$. $CoFe_2O_4$ has been extensively studied due to its interesting properties such as cubic magnetocrystalline anisotropy, high coercivity, moderate saturation magnetization, high chemical stability, wear resistance, and electrical insulation.[1–4] Since it was unclear up to now if additional structures and saturation in the magnetization would occur at low temperatures and very high magnetic fields (35 T) a systematic magnetization study of the $CoFe_2O_4$–$CoFe_2$ core-shell nanoparticles ferrite was performed.

Experimental

High resolution transmission electron microscopy (TEM) images were made using a JEM-ARM200F microscope at the NHMFL facility. The magnetization measurements were made by using a vibrating sample magnetometer (VSM) from room temperature down to 4.3 K at applied magnetic fields up to 35 T

Results and Discussion

TEM measurements show that dimension of the particles are close to the value determined by XRD (6.3 nm.) Fig. 1 shows the temperature dependence for the coercive (H_C) and exchange-bias (H_{EB}) fields (upper figure) and the variation of these parameters with the amount of ferrite present in the sample for T = 4.3 K (lower figure). The value for the coercive field for the pure ferrite sample (2.2 T) was the largest found to date for samples with similar average particle size. Furthermore, exchange-bias fields (H_{EB}) close to 0.16 T were also obtained. The magnetic properties of the CoFe-$CoFe_2O_4$ core-shell samples are influenced by the thickness and by its morphology, e.g., if the shell is amorphous or partially crystallized.

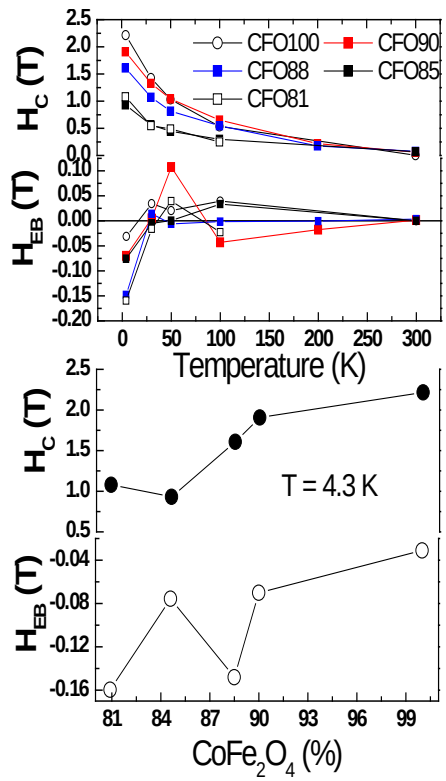

Figure 1 – T-dependence for H_C and for H_{EB} (upper figure) and their variation with the amount of ferrite (lower figure) for T = 4.3 K.

Conclusions

In summary, the magnetic properties of core-shell nanostructured particles of CoFe-$CoFe_2O_4$ were investigated as function of the temperature (4.3 – 300 K) in the high magnetic fields (35 T) regime. The coupling among the core-shell structure leads to the observation of the exchange-bias phenomenon. Enhancements of the coercive field and of the magnetocrystalline anisotropy constant were also observed which are due to the large number of defects on the surface of the particles, largely influencing the magnetic properties of nanostructured particle systems. Further analyses are underway to allow us to propose a better particle model which account for the observations presented in this report.

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