O-2

Size Distribution and Temperature Dependence of Magnetic Anisotropy Constant in Ferrite Nanoparticles

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Abstract

The temperature dependence of the effective magnetic anisotropy constant $K(T)$ of ferrite nanoparticles is obtained based on the measurements of SQUID magnetometry. For this end, a very simple but intuitive and direct method for determining the temperature dependence of anisotropy constant $K(T)$ in nanoparticles is introduced in this study. The anisotropy constant at a given temperature is determined by associating the particle size distribution $f(r)$ with the anisotropy energy barrier distribution $f_A(T)$.

In order to estimate the particle size distribution $f(r)$, the first quadrant part of the hysteresis loop is fitted to the classical Langevin function weight-averaged with the log-normal distribution, slightly modified from the original Chantrell's distribution function.[1]

In order to get an anisotropy energy barrier distribution $f_{\mathrm{A}}(T)$, the temperature dependence of magnetization decay M_{TD} of the sample is measured. For this measurement, the sample is cooled from room temperature to 5 K in a magnetic field of 100 G. Then the applied field is turned off and the remanent magnetization is measured on stepwise increasing the temperature.

And the energy barrier distribution $f_{\mathrm{A}}(T)$ is obtained by differentiating the magnetization decay curve at any temperature [2]. It decreases with increasing temperature and finally vanishes when all the particles in the sample are unblocked.

As a next step, a relation between r and T_{B} is determined from the particle size distribution $f(r)$ and the anisotropy energy barrier distribution $f_{\mathrm{A}}(T)$. Under the simple assumption that the superparamagnetic fraction of cumulative area in particle size distribution at a temperature is equal to the fraction of anisotropy energy barrier overcome at that temperature in the anisotropy energy barrier distribution, we can get a relation between r and T_{B}, from which the temperature dependence of the magnetic anisotropy constant was determined, as is represented in the inset of Fig. 1.

Substituting the values of r and T_{B} into the Néel-Arrhenius equation with the attempt time fixed to 10^{-9} s and measuring time being 100 s which is suitable for conventional magnetic measurement, the anisotropy constant $K(T)$ is estimated as a function of temperature (Fig. 1).

As an example, the resultant effective magnetic anisotropy constant $K(T)$ of manganese ferrite decreases with increasing temperature from 8.5×10^4 J/m^3 at 5 K to 0.35×10^4 J/m^3 at 125 K. The reported value for K in the literatures is 0.25×10^4 J/m^3.[3] The anisotropy constant at low temperature region is far more than one order of magnitude larger than that at 125 K, indicative of the effects of inter-particle interaction, which is more pronounced for smaller particles.

참고문헌

[1] S.-H.Yoon, M. Gonzales-Weimuller, Y.-C. Lee, and Kannan M. Krishnan, J. Appl. Phys. **105**, 07B507

(2009).
[2] A. J. Rondinon, A. C. S. Samia, and Z. J. Zhang, Appl. Phys. Lett. **76**, 3624 (2000).
[3] V. A. M. Brabers, in *Handbook of Magnetic Materials*, edited by K. H. J. Buschow (Elsevier Science, Amsterdam, 1995), Vol. 8, Chap. 3.