A7

A NEW METHOD TO OBTAIN M-H HYSTERESIS LOOP OF THE MATERIAL HAVING SMALL CRYSTALLINE ANISOTROPY

Department of Physics, KAIST, Jeen Hur*
Sung-Chul Shin

1. Introduction

The measurement of M-H hysteresis loop is essential to understand and develop magnetic materials. A vibrating sample magnetometer(VSM) is commonly used to measure $M-H$ hysteresis loops[1]. Several torque magnetometric methods[2-4] have been suggested for measuring the saturation magnetization as well as the uniaxial anisotropy energy constant. Recently, we have developed techniques to determine the M-H hysteresis loop of an uniaxial magnetic materials using a torque magnetometer[5-8]. In this paper, we report a new torque magnetometric method to obtain $M-H$ hysteresis loop of the uniaxial magnetic material having a much smaller crystalline anisotropy compared to a shape anisotorpy.

2. Experiment

The procedure for the measurement of the hysteresis loop is as follows; First slightly tilt the field direction by ϕ from the easy direction. Then, obtain the $\tau-H$ hysteresis loop by measuring the torque $\tau(H)$ as a function of H swept from the negative to the positive saturated field intensity. One can finally obtain the $M-H$ hysteresis loop by numerically solving M in the approximate relation, $M = \tau(H)/H\sin(\phi/(1+\frac{H}{NM}))$ where N is the demagnetization factor of the sample.

The inaccuracy of our method mainly results from including the crystalline anisotropy is approximately expressed by $\pm\frac{2K_U}{NM^2}$ where, K_U is the crystalline anisotropy constant. And, the uncertainty in M results from the measurement uncertainties in H, τ, and ϕ is expressed by $\frac{\Delta M}{M(H)} = -\frac{\Delta H}{H} -(1+\frac{H}{NM})\frac{\Delta\phi}{\phi}$. Here, ΔM, ΔH, $\Delta\tau$, and $\Delta\phi$ are the measurement uncertainties in $M(H)$, H, τ, and ϕ, respectively.

This method was applied to obtain $M-H$ hysteresis loops of Ni wire. The ratio of the crystalline anisotropy to the shape anisotorpy of this sample is less than 10^{-3}. A home-built torque magnetometer[9], having a 0.002-$dyne\cdot cm$-resolution in the measurement range of

5- *dyne·cm*, has been used. The small signal from the sample holder and substrate was subtracted out in the torque measurement.

3. Result and discussion

We deficited the τ-H hysteresis loop and the M-H hysteresis loop of the Ni wire having the diameter of 0.127 mm and the length of 5 mm, respectively, in Fig. 1(a) and 1(b). We obtain the very high sensitivity of about 10^{-6} emu in measuring the megnetization in the high-field regime. The inaccuracy of the present method caused by the first and the second term terms in the previous equation become negligible in a high-field regime. Hence, a better accuracy is achieved for a higher applied field. It should be mentioned that the accuracy of the magnetization measurement is negligibly affected even if one includes the higher order terms of the anisotropy energy.

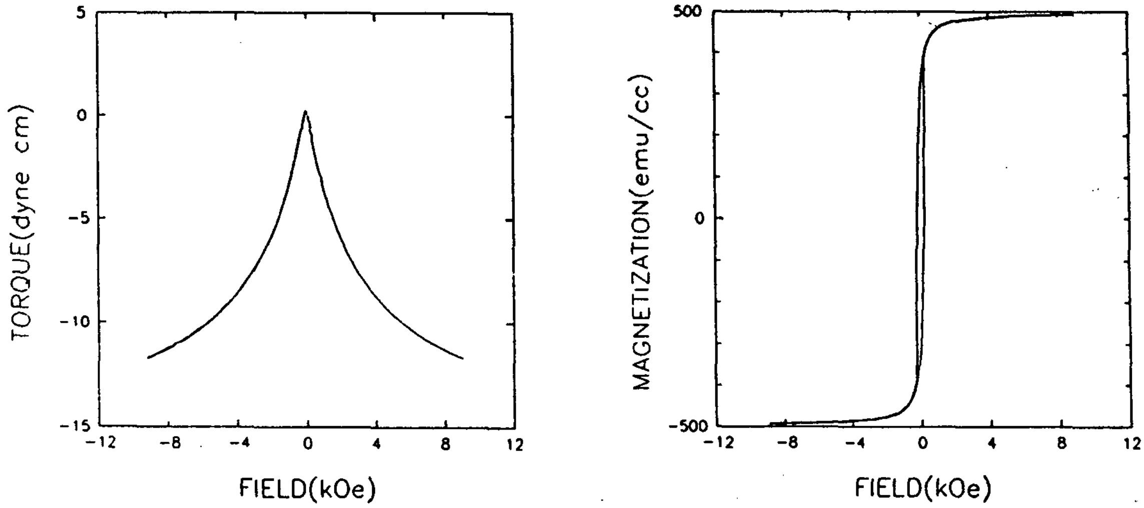

Fig. 1. The τ-H hysteresis loop in (a) and the M-H hysteresis loop in (b).

4. References

[1] H. Zijlstra, Experimental Methods in Magnetism (North-Holland, New York, 1987), Vol. 1, Chap. 3.

[2] H. Miyajima, K. Sato, and T. Mizoguchi, J. Appl. Phys. 47, 4469 (1976).

[3] T. Wielinga, J. Appl. Phys. 50, 4888 (1979).

[4] G. Pastor and M. Torres, J. Appl. Phys. 58 , 920 (1985).

[5] J. Hur and S.-C. Shin, Appl. Phys. Lett. 62, 2140 (1993).

[6] J. Hur and S.-C. Shin, Korean Magenetic Society Digest, A5, 24 (fall, 1993).

[7] J. Hur and S.-C. Shin, Korean Appl. Phys., 7(2), 79 (1994).

[8] J. Hur and S.-C. Shin, Technical Digest of MORIS, 114 (1994).

[9] J. Hur and S.-C. Shin, Korean Appl. Phys. 5, 363 (1992).