Available online at www.sciencedirect.com
SCIENCE DIRECT®
ELSEVIER
Journal of Magnetism and Magnetic Materials 272–276 (2004) e501–e502
Journal of magnetism and magnetic materials
www.elsevier.com/locate/jmmm

Micromagnetic torque studies of the intergranular exchange coupling and magnetocrystalline anisotropy in longitudinal recording media

F.Y. Ogrin[a,*], S.L. Lee[b], C.J. Oates[b]

[a] School of Physics, University of Exeter, Stocker Road, Exeter EX4 4QL, UK
[b] School of Physics and Astronomy, University of St. Andrews, KY16 9SS, UK

Abstract

Effects of the anisotropy and intergranular interaction in longitudinal media have been studied experimentally using micromagnetic simulation of torque. Two samples with different noise characteristics were compared in terms of the mean anisotropy field H_k, H_k distribution and exchange coupling stiffness C^*. Simulation results showed very good agreement with the results previously produced with other techniques, including TEM, FMR, Vector VSM, Delta-M and Delta-T.

Keywords: Longitudinal magnetic recording media; Intergranular coupling; Magnetocrystalline anisotropy

In this article we compare two media samples with different noise characteristics and investigate the noise in terms of possible variations of the intergranular exchange coupling, the anisotropy field and its distribution. The samples have been previously characterised by a range of techniques including TEM, FMR, Vector VSM, Delta-M and Delta-T [1–4], which gave us an initial range of parameters for the analysis of the torque data. Here we use micromagnetic modelling of torque [4] to simulate experimental data from the two samples and extract parameters of the anisotropy field H_k, exchange coupling C^* and anisotropy field distribution.

Figs. 1 and 2 show examples of torque measurements as functions of applied field for high and low noise samples 15A and 15B. All measurements were carried out at low temperature (2 K) to avoid switching of moments by thermal activation. The solid lines on the figures represent the result of simulations that give the best possible visual fit.

It has been found that, although the samples had a different grain size distribution the average value of the anisotropy field for both samples was very similar and equal to 10.6 kOe for sample 15A and 10.0 kOe for sample 15B. The distribution of H_k values, however, was significantly different. As seen from Fig. 2 and the inset, the low-noise sample 15B has a relatively narrow Gaussian distribution of H_k values with dispersion value $\sigma = 1.1$. In contrast, the high-noise sample shows a significantly broader distribution of H_k following a lognormal dependence with dispersion value $\sigma = 0.3$. Both results reflect the distributions of grain size, which are drastically different for the two samples. Low-noise 15B has an average size of 17 nm (as detected by TEM [1]) with a dispersion of 10%, whereas the high-noise sample 15A has very irregular shaped grains ranging in size between 20 and 200 nm.

The reduced exchange coefficient C^*, related to the strength of the exchange coupling, have been found to be equal to 0.2 and 0.4 for 15B and 15A, respectively. Previously, from dynamic FMR measurements, it was found that the inhomogeneous linewidth broadening term, which reflects the relaxation process, was twice as large for the high-noise medium as for the low-noise medium [3]. It was suggested that the difference could be as a result of an increased exchange coupling, which is indirectly related to the relaxation time. Here we confirm

*Corresponding author. Tel.: +44-1392-264116; fax: +44-1392-264111.
E-mail address: f.y.ogrin@exeter.ac.uk (F.Y. Ogrin).

0304-8853/$ - see front matter
doi:10.1016/j.jmmm.2003.11.282

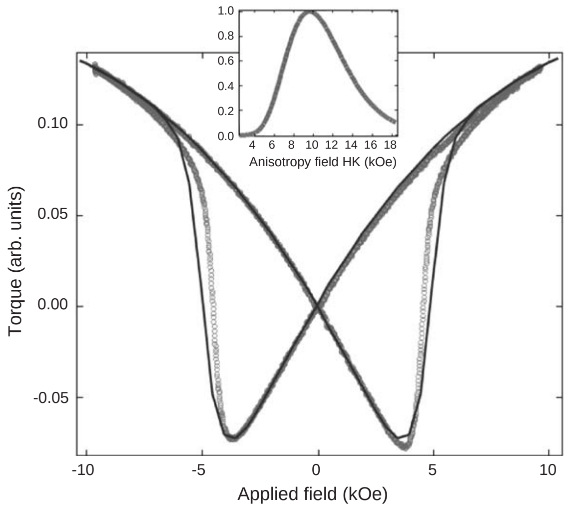

Fig. 1. Torque as a function of the applied field for a high-noise (15A) CoCrPtTa medium, as measured experimentally (symbols) and simulated (solid line) with the micromagnetic model. Temperature 2 K, applied field angle 40° to the plane. Inset: Lognormal distribution of H_k used in this fitting. Parameters: $C^* = 0.4$, $H_k = 10.6$ kOe, σ(lognormal) = 0.3.

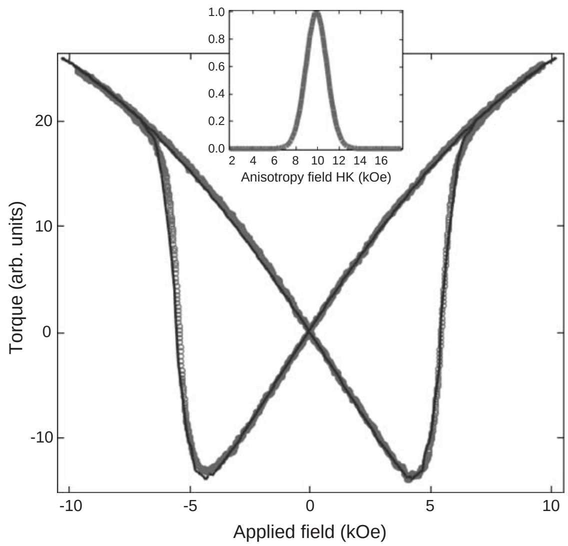

Fig. 2. Low-noise medium (15B). Inset: Gaussian distribution H_k used in the fitting. Parameters: $C^* = 0.2$, $H_k = 10.6$ kOe, σ(gaussian) = 1.1.

this suggestion by the results of the micromagnetic torque simulation, which indeed show an increased value (in fact, twice as large) in the exchange coupling constant for the medium with higher noise. Moreover, here we find that the anisotropy fields H_k for both samples are in very good agreement with those found earlier by FMR (10.8 and 10.7 kOe). It is interesting to note that the previous results of H_k measurements using mean-field modelling always indicated lower values (9.5 kOe). We believe that this discrepancy was due to the omission of the exchange coupling, which could not be included explicitly in a mean-field simulation. In fact, the difference of 0.5–1 kOe, between the values obtained by mean-field torque and FMR [4,3], is approximately equal to the decrease of the switching field value when the exchange coupling constant C^* is set to 0.2–0.4. This indicates that in magnetisation reversal the intergranular exchange coupling has an effect opposite to the anisotropy field. If a higher anisotropy is used to increase the switching field, the stronger coupling will lead to a decrease. This result seems logical, because a stronger intergranular coupling leads to a collective moment switching which would be most likely activated by the moments with the lowest energy barriers.

We would like to acknowledge Seagate Technology (Fremont) and T.Thomson for providing samples and useful discussions.

References

[1] E.T. Yen, S.Z. Wu, T. Thomson, R. Ristau, R. Ranjan, G.C. Rauch, IEEE Trans. Magn. 35 (1999) 2730.
[2] L. Holloway, L. Laidler, IEEE Trans. Magn. 37 (2001) 1459.
[3] C.J. Oates, F.Y. Ogrin, S.L. Lee, P.C. Riedi, G.M. Smith, T. Thomson, J. Appl. Phys. 91 (2002) 1417.
[4] F.Y. Ogrin, C.J. Oates, S.L. Lee, J. Magn. Magn. Mater. 242–245 (2002) 321.