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Demagnetising field reduction in keepered media

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Abstract

We have used a comparative study of time decay of magnetisation and thermal loss of signal in keepered and unkeepered recording media to obtain a measurement of the effective reduction in demagnetising field resulting from the keeper. By measuring magnetic viscosity in the recording layer of a CoCrTa media we have determined the loss of magnetisation per decade of time, over a wide range of fields around the coercivity. Measurements of recorded signal thermal loss effects in the same media both with and without a keeper layer exhibit a significant reduction in the thermal loss from 2.8% to 1.1% per decade of time due to the keeper. Comparison with the bulk time dependence data shows that this corresponds to a reduction in the effective demagnetising field from 1786 to 1493 Oe which moves the demagnetising field away from the edge of the switching field distribution onto the flat portion of the hysteresis loop.

Keywords: Keepered media; Thin film media; Magnetic properties

1. Introduction

Significant improvements in recording performance have been reported in CoCrTa thin film recording media where a soft magnetic (keeper) layer is deposited on top of the hard magnetic storage layer [1]. Furthermore since the soft keeper layer is magnetically coupled to the storage layer the effective demagnetising field present within the media is reduced and it has been found to narrow the transition length by around 10% after recording [2]. This local demagnetising field is of the order of 0.4 M_s (where M_s is the saturation magnetisation) for a data density of 5000 fr/mm [3] and it brings the grains within a bit into the switching region on the hysteresis curve hence there is time dependence of magnetisation occurring among the grains subject to the demagnetising field.

Time dependence of magnetisation arises from thermal activation of reversal and generally results in a drift in magnetisation, the direction of which is towards saturation in the direction of the applied field. It has been found that the time dependent loss in the magnetisation generally follows a quasi-logarithmic law [4]:

$$M(t) = M(0) - S \ln t. \tag{1}$$

The magnetic viscosity, $S = -\,\mathrm{d}M/\mathrm{d}\ln t$ is given by $S = 2M_s kTf(E)$ where $f(E)$ is the absolute value of the energy barrier distribution at the active point on the energy surface i.e at the critical energy barrier which is undergoing thermal activation in the field applied [4]. Thus if the value of $f(E)$ is constant during the time of measurement then an $\ln t$ variation of magnetisation with time is to be expected. However, if the energy barrier distribution is narrow it is reasonable to assume that the value of $f(E)$ is not constant during the time of measurement and under these conditions non-linear behaviour results which can be represented by sum of lnt variations where each $\ln t$ variation represents a given value of $f(E)$

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[4]. Hence all magnetic materials having distributed energy barriers are observed to exhibit time dependence of magnetisation which follows either a simple or a series logarithmic law. For the linear case the parameter $S(H)$ goes through a peak in the region of the coercivity which is in fact much closer to the peak in the differentiated remanence curve since the value of $S(H)$ mirrors the value of the energy barrier distribution within the system [5].

In written transitions the demagnetising field from the bit itself and from neighbouring bits gives rise to a time dependent loss of signal. This variation in pulse amplitude is related to the value of the magnetisation within the bit and hence by measuring the logarithmic rate of decay of pulse amplitude the effective demagnetising field on the bit can be determined by a comparison with time dependence measurements made on the hysteresis loop. In this brief study an evaluation of this effective reduction in the demagnetising field has been made on a CoCrTa film using Sendust as the keeper layer and has been used to establish the effects of the keeper layer.

2. Experimental

In this study we have examined two identical $CoCr_{12}Ta_2$ longitudinal thin film disks prepared by sputtering, one with a keeper layer and one without. Sendust was used as a keeper layer and this was separated from the hard magnetic layer by a thin exchange breaking layer of Cr. The recording performance measurements were made on a spin-stand at a data density of 5000 fr/mm. Further details of the deposition and recording measurements are described elsewhere [6].

All magnetic measurements were made using an alternating gradient force magnetometer on samples cut from the disks. Measurements of time dependence were made by first saturating the samples in a positive field whereafter the field was reduced to zero and a negative field applied which brought the sample into the switching region, i.e. the region of the coercivity. At this point the field sweep was stopped and the variation of magnetisation with time recorded each second for a period of 10 min. For each new measurement the sample was re-saturated and the measurement procedure repeated. For both samples and for all fields examined an almost exactly linear variation of magnetisation with time was observed indicating that the samples possessed fairly broad distributions of energy barriers. The actual energy barrier distribution was determined via the measurement of the demagnetising remanence (DCD) curve obtained by applying successively larger negative fields again to a sample previous saturated in a positive direction.

3. Results and discussion

The hysteresis loops for the unkeepered and keepered samples are shown in Fig. 1 and the effect of the keeper layer is clear by inspecting these loops. From the loop of the unkeepered sample the hard layer, i.e. the recording layer, has a coercivity of the order of 2.2 kOe and a well defined hysteresis loop of moderate squareness 0.81 and a moderate value of S^* of 0.71. In the case of the keepered film however these parameters are ill-defined due to the effects of the soft layer on the shape of the hysteresis loop. The recorded signal thermal loss measurements have been reported more fully in a previous publication [6] but the keepered sample exhibited a significant reduction in the thermal loss from 2.8% to 1.1% per decade of time due to the keeper.

The time dependence data for the keepered film shown in Fig. 2 confirms that an almost exact linear variation in $\ln t$ is seen. The slopes of these variations were then normalised to the initial value of magnetisation (i.e. at $t = 0$), for the purpose of calculating the percentage loss of magnetisation per decade. Fig. 3 shows a plot of these gradients against field for the keepered disk. The reduction in demagnetising field was then obtained by using the reduction in recorded signal loss reported above as shown by the lines marked on Fig. 3. Inspection of this graph shows that the effective demagnetising field was reduced from 1786 Oe to 1493 Oe, i.e. a reduction of about 300 Oe. Whilst this reduction may appear to be small it moves the demagnetising field away from the edge of the switching field distribution onto the flat portion of the hysteresis loop or, more specifically, the energy barrier distribution.

Fig. 4 shows the switching field distribution of the keepered sample obtained by differentiating the DCD curve and normalising the area under the curve to unity.

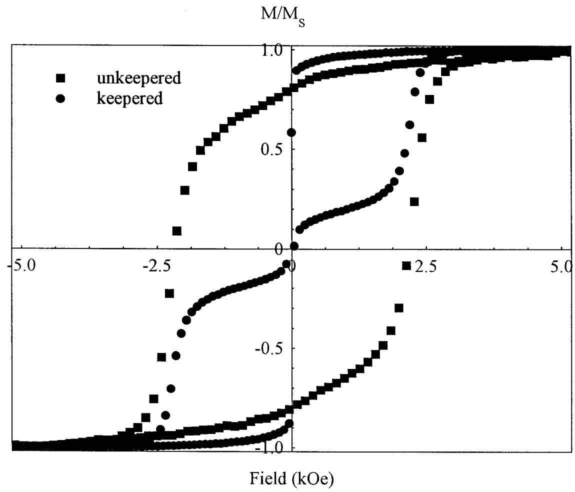

Fig. 1. Hysteresis loops of the keepered and unkeepered samples.

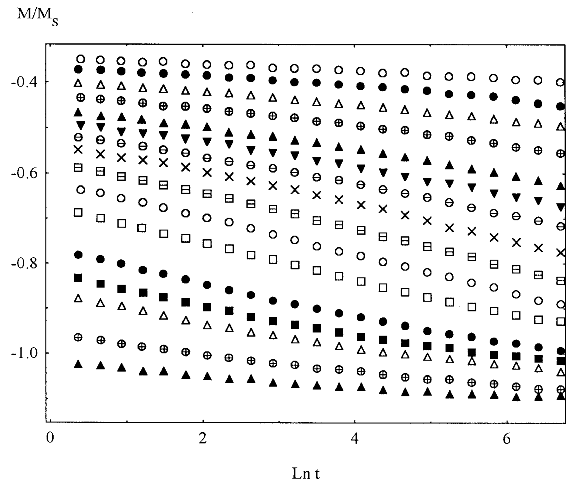

Fig. 2. Time dependence data for the keepered media.

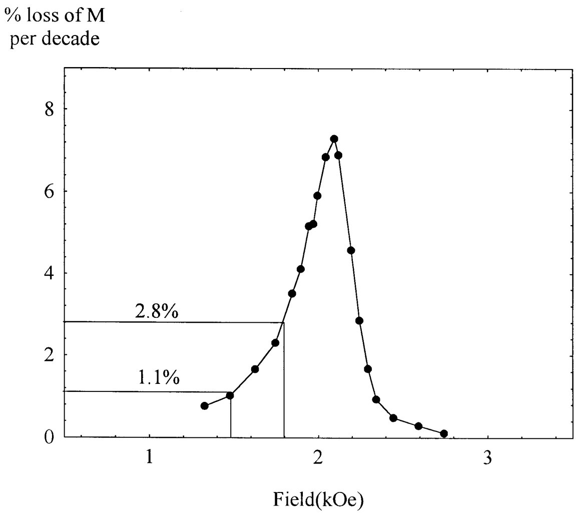

Fig. 3. Loss of magnetisation per decade of time as a function of applied field for the keepered media.

We have marked on this figure the region of the energy barrier distribution corresponding to the demagnetising field of the keepered (Hd keep) and unkeepered (Hd unkeep) samples and it clearly illustrates that the effect of the keeper has been to move the effective demagnetising

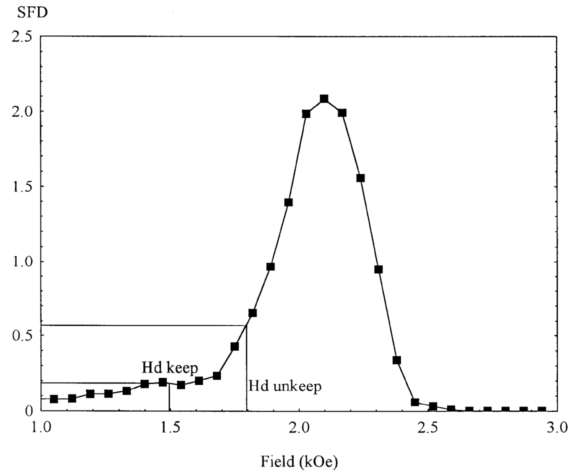

Fig. 4. Switching field distribution for the keepered media obtained by differentiating the DCD curve.

field away from the switching region where thermal loss effects become much more significant.

In conclusion we have showed that inclusion of a keeper layer on top of the CoCrTa recording layer in these media results in a reduction in the local demagnetising field of about 300 Oe which is sufficient to move it away from the switching region of the loop thereby reducing thermal loss. We would therefore expect that the keepered medium could support an increase in linear density of the order of 20% before thermal loss again becomes significant.

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