THE INFLUENCE OF DEMAGNETIZATION ON THE MAGNETIC AFTER-EFFECT OF Co-Cr MICROSTRUCTURES.

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Introduction.

Time dependence of magnetic storage media is of practical interest in long term stability and high frequency writing. For Co-Cr media with a perpendicular effective magnetic anisotropy ($K_{eff} > 0$) the remanent magnetization is found to decay quasi-logarithmic with time [1,2] and to depend on the demagnetizing field H_d . A dependence on H_d was observed experimentally by Lottis et al. [2] who measured the decay in readback signal of a written bit pattern. However the relation with the demagnetization factor N_z was not quantified.

Therefore in this paper the time dependence of as-sputtered and patterned Co-Cr is discussed. The patterned CoCr has a structure as in [2] (see figure 1), and exhibits a $N_z < 1$. N_z was obtained experimentally by VSM and torque measurements, as described in [3]. The influence of a theoretically calculated N_z on the time dependence of the remanent magnetization is simulated.

figure 1.
Dimensions and notation of the Co-Cr pattern.

Experimental.

Co-Cr was RF sputtered under optimized conditions [4]. The pattern was obtained by ion-beam etching, leaving the intrinsic magnetic properties unaffected. However the demagnetization difference influences the shearing of the hysteresis curve (figure 2). For time dependent measurements the films were initially saturated to minus 1000 kA/m and then the field was set within 12 seconds to a constant value. The magnetic moment was monitored for 1 hour. The measurements were performed at room temperature. The most relevant magnetic properties are listed in table 1.

figure 2.
Perpendicular hysteresis curves of 140391-10 (solid line) and 140391-9 (dashed line)

figure 3.
Remanent decay of Co-Cr showing the influence of H_d

Results.

In figure 3 the time dependence of the normalized remanent magnetization M_r/M_s is shown. Samples nr. 10 exhibit slower decays. This effect is due to a lower demagnetizing field ($H_d = N_z M_r$). The absolute values of the samples nr. 10 are lower because of their lower M_r (see figure 2).

In figure 4 the decrease per 'e-cade' of time S is given as a function of the applied field. The as-sputtered sample shows an almost constant behaviour (open squares). The patterned sample (filled squares) slowly decreases towards the value of the open squares. Note that there is no maximum value of S near coercivity, as is observed in in-plane media, but that a small increase can be observed around -50 kA/m.

figure 4.
Magnetic after-effect as a function of H_{app}

figure 5.
Simulation of the time dependence of M_r for different demagnetization factors.

Simulation.

The influence of N_z on the remanent decay can be simulated using the modified Neel model [1], by inserting N_z in the demagnetizing term. In figure 5 an example is given which clearly features a slower decay with decreasing N_z . In this figure also two 'time windows' regions, as observed in [5], can be defined. When calculating the N_z of our patterned samples (N_z^p) and the written bit pattern (N_z^b) in ref. 2, it can be concluded that $N_z^b < N_z^p < 1$ (the calculation is based on multiple Fourier series [6] and the pattern having equal dimensions). These results support the conclusions in reference 2 that the slower decay in signal with time decreases with increasing bit density.

table 1.

Sample name	t [nm]	Ms [kA/m]	Mr [kA/m]	Nz	K1 [kJ/m ³]	Hc [kA/m]	Lx [μm]	Ly [μm]	W [μm]	l [μm]
140391-9	430	532	164	0.83	200	86	2	20	1	5
140391-10	430	532	119	1	200	83	as-sputtered			
120291-9	430	382	125	0.91	111	64	2	20	1	5
120291-10	430	382	79	1	111	66	as-sputtered			

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