DOMAIN STRUCTURES IN Co/Pd MULTILAYERS

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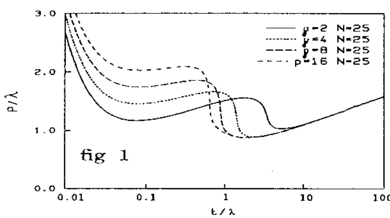
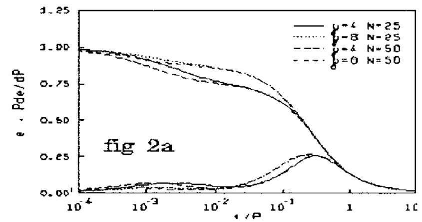
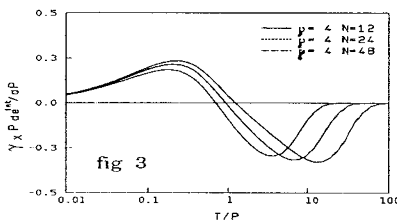
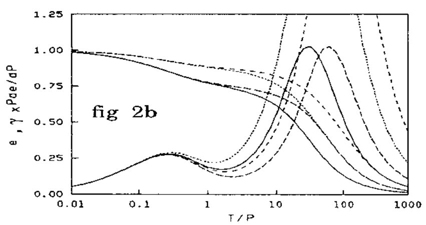
Potential application of mutilayers (ML) in magneto-optical recording is connected with the problem of information stability, which in turn mostly depends on the coercivity but also on the magnetostatic forces in metastable domain configurations. Our aim is to discuss the periodic domain model for ML [1-3] and to compare its predictions with domain observation, the slopes of M-H loops and the anisotropy constants of medium and high coercivity Co/Pd ML.

The periodic stripe model [1-3] balances the magnetostatic forces with surface tension in domain walls. As seen in Fig.1, we find that it predicts a non-monotonous dependence of the equilibrium stripe period P on the total ML thickness T, or the individual magnetic layer thickness t, if they decrease proportionally at constant number of layers N and constant proportion γ of total to magnetic volume: γ=T/Nt. To understand this behavior we plot in Fig. 2 the normalized magnetostatic energy density $e = 2E/\mu_0 M_s^2$ [2,3] and the average magnetostatic force per unit wall area $\Phi = P\partial e/\partial P$ as functions of the domain period realative to t and T . At balance, $\Phi = 2\lambda P_0$ if $\lambda = 2\sigma/\mu_0 M_s^2$, σ is the wall energy density. As indicated by the different scales in Figs.2a,b, the low-P and high-P maxima in Φ are shape resonance effects around P≈t and P≈T, resp. In Fig 3 we plot the part of Φ due to inter-layer forces alone: around P≈T this is the main part of Φ which tends to shrink the domains, while at higher T/P it has the opposite tendency. Prevalence of inter-layer interactions in the high-P region is the reason why, in this region [1-3],the ML behavior is practically determined by the macroscopic parameters T and γ: the maximum Φ (i.e.,









minimum equilib. P) occurs at $T \cong 2\gamma\lambda$ (with $P \cong 7\gamma\lambda$), which would also be predicted for a single layer of thickness T, mean magnetization M_s/γ and accordingly diluted mean wall energy σ/γ.

We have also computed the initial slopes of M(H) curves from the model [2,3]. Comparison of the computed and observed domain periods as well as of the M(H) slopes around M=0 allows to estimate the domain wall energy.

Samples of Co/Pd ML were prepared by rf sputtering in Ar ,M-H loops were measured by VSM and anisotropy constants K_{ef} by a torque magnetometer [4]. Domain structures were studied using the Bitter-colloid patterns observed by SEM, on the M-H loops and on minor loops after a number of cycles. Examples of the observed domain structures are in Figs. 4 a,b for a medium and high coercitivity sample, resp. The sample parameters and preliminary results are in Table 1:

	t_{Co}	T	γ	M_s	K_{ef}	K_u	dH/dM	H_c	P	λ	σ_P	σ_K
	nm	nm		MA/m	MJm^{-3}			kA/m	nm	nm	mJm^{-2}	
a	0.85	57.4	2.7	1.85	0.4	2.5	0.21	36	70-100	3-4	6	20
b	0.43	83.9	7.9	1.6	1.6	3.2	0.05	110	250-300	4.5-5.5	8	22

Here $K_u = K_{ef} - \mu_0 M_s^2/2$, both K_u and M_s refer to Co volume (25 layers). The mean domain period P is estimated on minor loops. The characteristic length is estimated as $\lambda = \Phi P/2$ with Φ obtained using the experimental T/P ratio and the model. Domains in the "hard" sample (b) are apparently very close to the minimum period predicted by the model. The estimate of λ agrees within the large uncertainty limits with that obtained comparing the measured and computed dH/dM at $H=H_c$. Finally, σ_P is the wall energy density estimated as $\lambda(\mu_0 M_s^2/2)$ from the domain period, while $\sigma_K = 4(AK_u)^{1/2}$ is the classical energy density expected using the measured K_u and estimated $A = 10^{-11}$ J/m^3. The experimental values are considerably higher than those reported previously [2,3] but still much lower than the expectation based on K_u alone; obviously, the (negative) dipolar energy of a realistic wall configuration should partly correct this discrepancy.

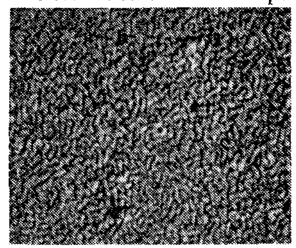
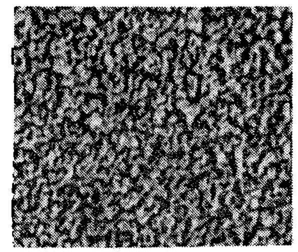


fig-4 a↑ b↓ —— 1µm



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