MO SIGNAL IN CO-PT AND CO-PD ALLOY DISKS: COMPARISON TO RESPECTIVE MULTILAYERS AND TBFeCO

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Abstract—A wavelength dependent, quantitative comparison of the static magneto-optical signal in Co-Pt and Co-Pd alloys, Co/Pt and Co/Pd multilayers and TbFeCo has been carried out. Dynamic testing of evaporated Co-Pt and Co-Pd alloys, embedded in quadrilayer structures has been demonstrated at 488nm. Large mark CNR ratios above 60dB in Co-Pt alloys were found on ungrooved glass disks.

KEYWORDS: MO RECORDING IN CO-PT AND CO-PD ALLOYS, MAGNETO-OPTICAL SPECTROSCOPY

INTRODUCTION

Co/Pt and Co/Pd multilayers show MO signal advantages at short wavelengths compared with TbFeCo or GdTbFe, which are currently used in MO recording products [1-3]. In the case of Co/Pt a ≈ 3 dB performance improvement has been demonstrated in dynamic testing at wavelengths of 488nm [4] and 458nm [5]. This was attributed to the larger Kerr effect of these materials at short wavelengths.

Respective Co-Pt and Co-Pd alloy systems have been suggested recently for MO recording [6, 7], as they promise even better performance compared to their multilayer counterparts. Lin et al. [8], Weller et al. [6], and Farrow et al. [9] showed, that evaporated $\text{Co}_{\sim 30}\text{Pt}_{\sim 70}$ alloys can indeed fulfill all the necessary prerequisites for MO recording. Key to establishing perpendicular magnetic anisotropy and suitable coercivities in Co-Pt is an elevated deposition temperature in the range 200-300°C and a Pt content near 70at%. The latter also controls the Curie temperature, which is chosen near 250°C for MO recording films. We mention, that the present alloys are different from those reported in 1975 by Treves et al. [10], who investigated the tetragonally distorted Co-Pt L_{10} phase near the $\text{Co}_{50}\text{Pt}_{50}$ composition. Tsunashima et al. [11] and Hashimoto et al. [2] already in 1989 reported evaporated and sputtered Co-Pd alloys with perpendicular magnetic anisotropy, which they attributed to strain in conjunction with large negative magnetostriction coefficients. Hashimoto et al. [2] also reported that respective sputtered Co-Pt alloys were in-plane. Carcia and Zeper [12] for the first time in 1990 mentioned the possibility of perpendicular magnetic anisotropy in high Ar pressure deposited alloy like "multilayers".

In this paper, we focus on a quantitative signal comparison of Co-Pt and Co-Pd MO recording disks

in the wavelength range 1580-245nm (0.8-5eV photon energy) and compare the results to TbFeCo. Thermomagnetic writing in $\text{Co}_{\sim 30}\text{Pt}_{\sim 70}$ and $\text{Co}_{\sim 30}\text{Pd}_{\sim 70}$ alloys is demonstrated for the first time.

EXPERIMENTAL

The present alloys and multilayers were evaporated in HV at substrate temperatures of $\sim 50^\circ\text{C}$ and $200\text{--}250^\circ\text{C}$, respectively, on differently buffered substrates [6]. Both thick single films ($d > 100\text{nm}$) and quadrilayer disks were investigated with an automated Kerr spectrometer [13]. The disks were made on 5.25"-diameter flat glass substrates in quadrilayer structures of the type D1/MO/D2/R. The dielectric layers D1 and D2 are reactively rf-diode sputtered SiN_x films and the reflector layer R is dc-magnetron sputtered Al. These layers were kept unchanged in the present comparison. For the active MO layer optimized films of CoPt, CoPd and TbFeCo were chosen. Co/Pt multilayers, Co-Pt alloys and Co-Pd alloys were evaporated in HV and Co/Pd multilayers were deposited by sputtering. Additionally, MBE grown Co-Pt alloy films were investigated, as they showed a considerably higher coercivity ($> 4\text{kOe}$) than the respective HV deposited Co-Pt alloys [9]. The compositions and thickness ratios - in the case of multilayers - were determined with X-ray diffraction and X-ray fluorescence. Dynamic testing experiments were performed at 488nm with a system described by Hurst et al. [14].

RESULTS AND DISCUSSION

We define the static MO signal as the product of the disk reflectivity R and the complex Kerr effect $|\Phi| = (\theta_K^2 + \epsilon_K^2)^{1/2}$. This can be measured by separately determining the reflectivity R , the Kerr ro-

Fig.1: Static MO signal $R \times (\theta_K^2 + \epsilon_K^2)^{1/2}$ of ($\geq 100\text{nm}$) thick Co-Pd and Co-Pt alloys, Co/Pt and Co/Pd multilayers and TbFeCo as function of the photon energy (0.8-5eV). The compositions are indicated in the figure.

tation θ_K and the Kerr ellipticity ϵ_K . Fig.1 shows a static signal comparison of several at least 100nm thick films, measured in remanence from the air side in the range 0.8-5.0eV. It is important to include ϵ_K in the signal evaluation, as this can contribute considerably, especially in the case of the present alloys. The compositions and thickness ratios, as indicated in the figure, were chosen such, that large perpendicular magnetic anisotropies ($K_u \sim 0.5\text{MJ/m}^3$) and suitable Curie temperatures (200-300°C) for MO recording were obtained. As a result of this quantitative comparison we conclude that a considerable signal enhancement at short wavelengths $\lambda \leq 600\text{nm}$ ($E > 2\text{eV}$) can be expected in all of the investigated films. This is attributed to extra Kerr contributions from (via exchange interaction with Co) spin-polarized Pt and Pd bands in these systems. These give rise to the strong uv peaks at 4.0eV and 3.0eV in Fig.1 for the Pt and Pd systems, respectively. This latter point has recently been confirmed by ab-initio band structure and MO calculations by Sticht [15]. The larger Kerr effect of alloys as compared to multilayers is due to enhanced exchange in these systems [16, 17]. The largest enhancement with respect to $\text{Tb}_{23.5}(\text{Fe}_{90}\text{Co}_{10})_{76.5}$ is found in the $\text{Co}_{28}\text{Pt}_{72}$ alloy, which outperforms the other materials in view in the whole wavelength range, except in the far IR. At 428nm, which is the wavelength of a possible compact blue laser source [18], the enhancement amounts to a factor of 2.4 (7.5dB) in

Fig.2: As Fig.1 but as function of the wavelength (300-800nm). All measurements were made at room temperature and in remanence from the film/air side.

$\text{Co}_{28}\text{Pt}_{72}$, while Co/Pt multilayers and Co/Pd multilayers and alloys show smaller but still considerable enhancement factors of ≈ 1.7 (4.6dB) at that wavelength. This is best seen in an expanded plot in Fig.2, where we have plotted the MO signal as function of the wavelength in the range 300-800nm. Table 1 summarizes gain factors at 488nm and 428nm compared to TbFeCo. Note however, that these gain factors refer to single (thick) films only. The measured Kerr rotation and ellipticity data of the present Co-Pt alloy films together with ellipsometrically determined optical constants n and k were

Tab. 1: Experimentally determined MO signal gain factors at 488nm and 428nm for thick single films of different recording candidate materials: $\text{Co}_{28}\text{Pt}_{72}$ and $\text{Co}_{28}\text{Pd}_{72}$ alloys and $77x(0.28\text{Co}/1.02\text{Pt})$ and $77x(0.27\text{Co}/0.96\text{Pt})$ multilayers [nm] (gain factor $G = S_{\text{MO}}/S_{\text{TbFeCo}}$).

MO	G	20log(G)	G	20log(G)
	$\lambda = 488\text{nm}$		$\lambda = 428\text{nm}$	
Co-Pt	1.73	4.8dB	2.40	7.5dB
Co-Pd	1.46	3.3dB	1.82	5.2dB
Co/Pd	1.38	2.8dB	1.68	4.5dB
Co/Pt	1.31	2.3dB	1.68	4.5dB

used as input data for optical stack-design calculations. As a result of these calculations we made quadrilayers glass/D1/MO/D2/R for operation at 488nm with D1=40nm, MO=20nm, D2=20nm and R=50nm. D2 was chosen to be relatively thin and constitutes a compromise between optimal optical and thermal stacking. These parameters were kept constant for the following comparison of static and dynamic test results. Fig.3 shows the static MO signal data of the best performing quadrilayer disks made of the above materials. The measurements were carried out from the substrate side. The trends are similar to those in Fig.2, however the onset of optical absorption in glass near 400nm causes the reflectivity and therefore the signal to drop off below about 370nm. Note, that there are no distinct peak features in the signal spectra, which are clearly observed in the separate Kerr effect and reflectivity spectra, showing that R and $|\Phi|$ are essentially inversely related.

Table 2 lists the quadrilayer gain factors at 488nm, compared to TbFeCo and in addition contains large mark ($\sim 5\mu\text{m}$) CNR measurements obtained at 488nm with 2mW read power, 30kHz bandwidth and a disk velocity of 10m/s. Co-Pd alloys have not been included in this comparison so far, as we were not yet able to fabricate respective high coercivity alloy films without using metallic buffers (see e.g.[6, 8]). On a Co-Pd alloy based quadrilayer disk, we could nevertheless demonstrate write/read capability and have so far achieved a large mark CNR of 51dB. A 40Å thick Pd buffer was used and the coercivity of that disk was $\sim 800\text{Oe}$.

Tab. 2: Experimentally determined MO signal gain factors at 488nm of quadrilayers (D1=40nm, D2=20nm, MO=20nm, R=50nm) with MO=Co/Pt multilayers, Co/Pd multilayers and Co-Pt alloys. (Definitions as in Table I) Large mark CNR ratios (2mW read power, 1MHz signal frequency, 10m/s linear velocity)

MO	G	$20\log(G)$ $\lambda = 488\text{nm}$	CNR
Co/Pt	1.36	2.6dB	63.5dB
Co/Pd	0.91	-0.8dB	59.0dB
Co-Pt	1.64	4.3dB	61.7dB
(Co-Pd)	-----	-----	51.0dB

Fig.3: Static MO signal of quadrilayers (thicknesses in nm) vs wavelength measured in remanence through the glass substrate.

CONCLUSIONS

High performance Co/Pt and Co/Pd multilayer and (MBE grown) Co-Pt alloy based disks with large mark CNR ratios exceeding 59dB on flat glass disks have been demonstrated. CNR scales roughly with the static MO signal. Inferior performance of the Co-Pt alloy disks is attributed to extra write noise.

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