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Seedlayer and Preheating Effects on Crystallography and Recording Performance of CoCrPtB Perpendicular Media

Min Zheng, Geon Choe, Kenneth E. Johnson, Lan Gao, and Sy-Hwang Liou

Abstract—The effects of seedlayer (SL) and preheating on the crystallographic, magnetic, and recording properties of $\text{CoCr}_{18}\text{Pt}_{16}\text{B}_4$ granular perpendicular magnetic media have been investigated. For the media with Ru as underlayer, although higher preheating improves both coercivity and squareness, the media is much noisier. With introducing Ta SL, Ru (0002)/Co (0002) crystallography is greatly enhanced. High coercivity, unity squareness, and negative nucleation field are achieved even at low preheating without degrading signal-to-noise ratio. In addition, the media is magnetically stable for a wide range of recording density.

Index Terms—Crystallography, granular media, perpendicular recording, Ru UL, Ta SL, thermal stability.

I. INTRODUCTION

PERPENDICULAR magnetic recording (PMR) media have been considered as a promising candidate in order to achieve over 100 Gb/in² recording density [1]. However, thermal stability at low recording densities has been a concern especially for low-noise PMR media [2]. Achieving high perpendicular coercivity (H_c) and unity squareness ($SQ = Mr/Ms$) is necessary to improve thermal stability [2], [3] and has been proposed by using either high substrate temperature or post-annealing of CoCr-based granular films [4]. However, either of these two methods is not practical in current disk manufacturing and the influence of high heating on recording performance deserves further investigation. Ru is commonly used as underlayer (UL) for granular PMR media. It was found that thicker (>40 nm) Ru UL was required to provide narrower grain dispersion [5]. In this paper, we studied the seedlayer (SL) and preheating effects on the crystallographic, magnetic and recording properties of $\text{CoCr}_{18}\text{Pt}_{16}\text{B}_4$ granular PMR media. We report that the Ta SL (SL) developed in this paper greatly enhances UL Ru (0002) and Co (0002) crystallography H_c , SQ , and thermal stability without degrading media signal-to-noise ratio [represented by isolated pulse signal divided by rms media transition noise (So/Nm)]

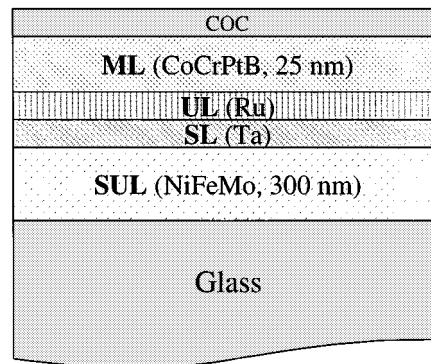


Fig. 1. Schematic view of PMR disk structure studied in this paper.

II. EXPERIMENT

All films were sputtered onto preheated 95-mm-diameter glass substrates. Two preheating temperature, 300 °C and 500 °C were studied. A schematic view of disk structure is given in Fig. 1. A 25-nm-thick CoCrPtB film was sputtered with a Ru UL or a Ta–Ru UL. A 300-nm-thick $\text{NiFe}_{17}\text{Mo}_4$ soft magnetic UL is used as keeper layer when measuring recording performance. Ta layer can also be sputtered prior to depositing soft magnetic layer to provide good adhesion. A protective carbon overcoat was used. The crystallographic orientation was characterized by X-ray diffraction (XRD). Magnetic properties were measured by a vibrating sample magnetometer (VSM). Recording performance was evaluated on a Guzik tester with single-pole writer and giant magnetoresistance reader.

III. RESULTS AND DISCUSSION

The unique property of Ta as a SL in the medium having Ru as UL for perpendicular recording is the substantially improved Co (0002) preferred orientation. Fig. 2 shows XRD pattern of CoCrPtB medium with and without Ta SL. The rocking curves are shown as insets. The thickness for Ta SL is 70 Å and XRD pattern confirms an amorphous structure. Ru UL thickness is 150 Å. With Ta SL, the intensity of (0002) diffraction peak is improved by a factor of ten compared with that without Ta SL. A much narrower rocking curve is achieved with Ta SL. As seen in the insets of Fig. 2, the rocking curve width is about 6° for the media with Ta SL compared with 16° for the media without Ta SL, illustrating a narrower dispersion of Co (0002) grains. Amorphous SL is found to provide a smoother and adsorbed impurity free surface and, thus, ensure the better aligned grain formation [6].

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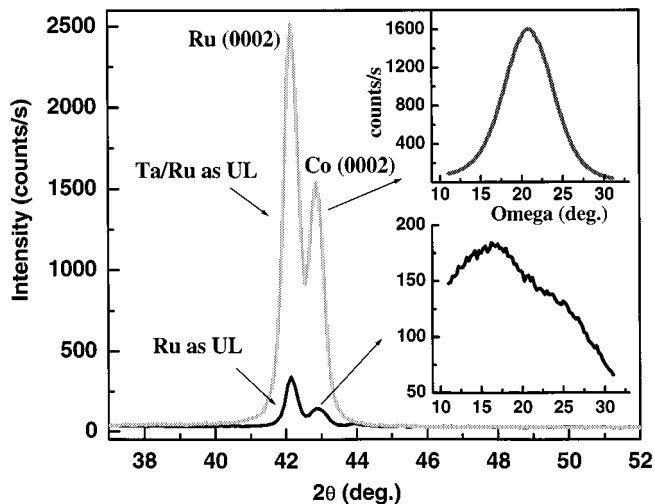


Fig. 2. XRD and rocking curves (inset) of $\text{CoCr}_{18}\text{Pt}_{16}\text{B}_4$ media using Ru (150 Å) and Ta (70 Å)/Ru (150 Å) UL.

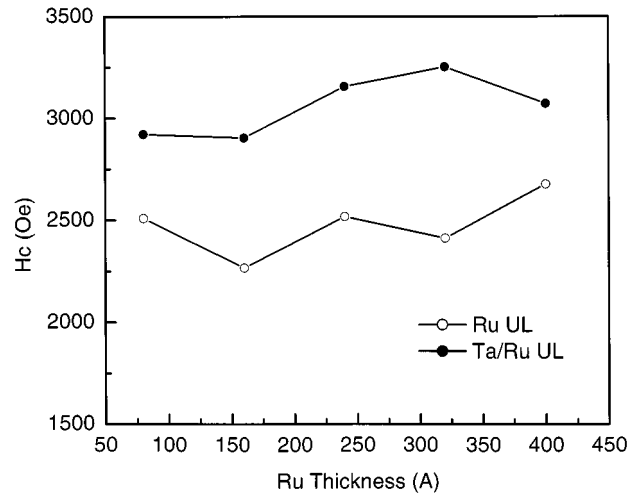


Fig. 4. Perpendicular coercivity dependence on Ru UL thickness for $\text{CoCr}_{18}\text{Pt}_{16}\text{B}_4$ media with/without a 70-Å-thick Ta SL.

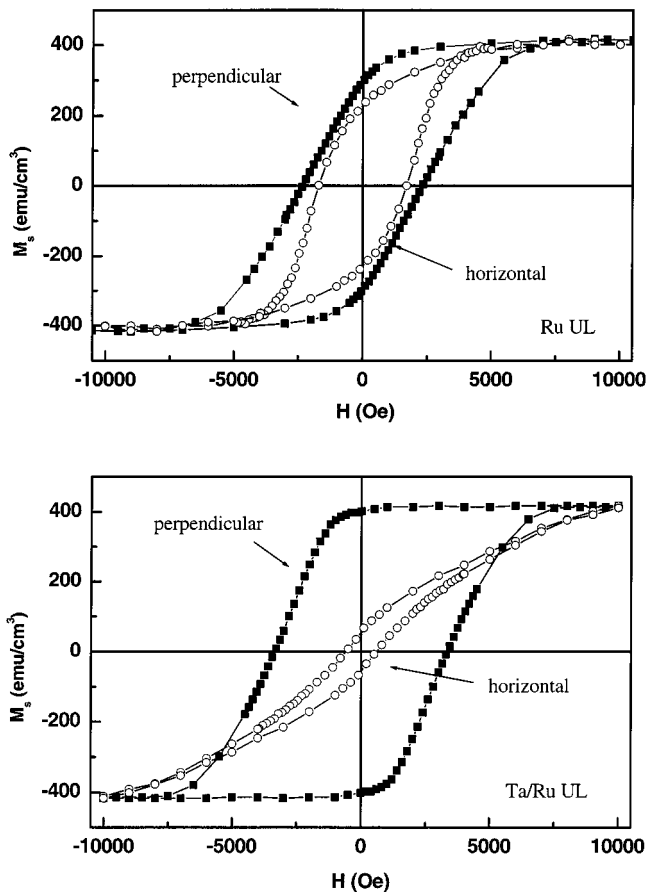


Fig. 3. Perpendicular M-H loops for $\text{CoCr}_{18}\text{Pt}_{16}\text{B}_4$ media deposited onto Ru (300 Å) or Ta (70 Å)/Ru (300 Å) UL.

Fig. 3 shows perpendicular and in-plane hysteresis loops for CoCrPtB media with Ru or Ta-Ru ULs sputtered at 300 °C preheated substrates. With Ta SL, the perpendicular squareness of the medium increases from 0.8 to 1 and a negative nucleation field is achieved. The medium has a weaker in-plane hysteresis loop. This is associated with narrower grain dispersion improved by using Ta SL. Fig. 4 shows the perpendicular co-

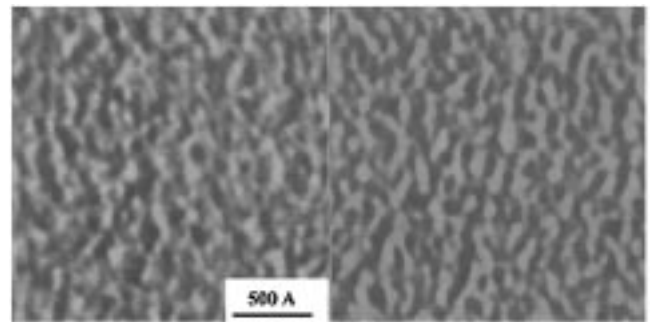


Fig. 5. MFM images for the medium without (left)/with (right) Ta SL.

ercivity dependence on Ru UL thickness for the media with or without Ta SL. The media having a Ta as SL exhibit higher coercivity at the same Ru UL thickness than those without Ta SL. In other words, Ru UL thickness can be greatly reduced by employing Ta SL for the media to achieve the same coercivity. This is important for perpendicular recording since the spacing from the pole head to soft magnetic UL is critical.

Magnetic force microscopy (MFM) images for the medium with or without Ta SL are shown in Fig. 5. MFM images were taken in the demagnetized states. No significant difference in terms of domain structure and domain size has been observed which implies that Ta SL should not increase medium noise. This is confirmed by the parametric testing results, as we will show later.

Thermal stability is a big concern for perpendicular magnetic recording, especially at low densities. Fig. 6 shows the thermal decay versus time at different densities for the medium with/without a Ta SL. The medium with Ta SL is more magnetically stable at wide range of recording densities. For example, thermal decay values at 200 KFCI for Ru and Ta-Ru UL media are $-2.05\%/decade$ and $-0.36\%/decade$, respectively. The improved thermal stability for the medium with Ta SL could be due to the unity squareness and negative nucleation field.

The preheating of the substrates also plays a role on the magnetic properties. For the medium with Ru UL, higher substrate temperature increases both perpendicular coercivity

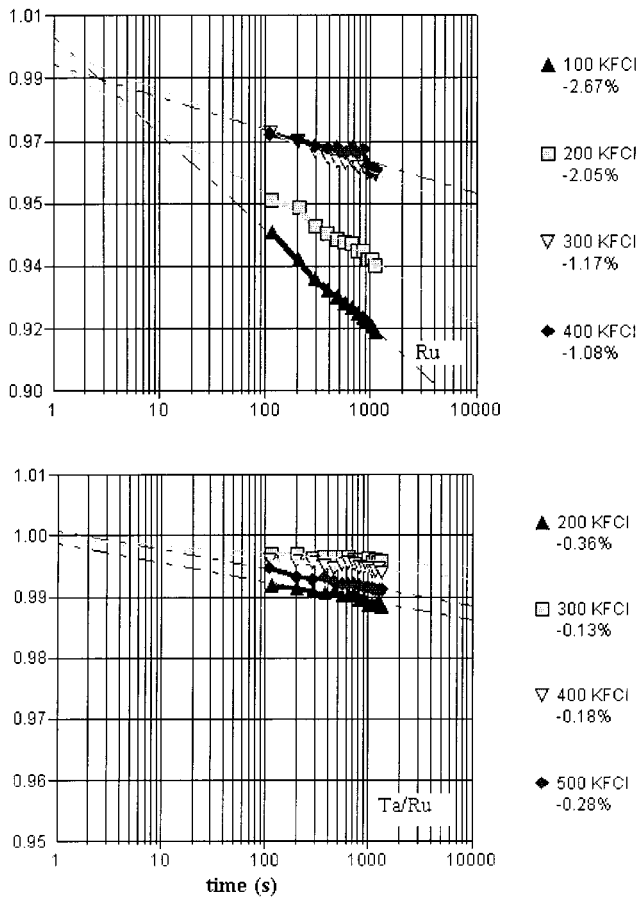


Fig. 6. Thermal decay at different density for the medium with Ta or without Ta SL.

and squareness. However, the medium becomes much noisier. For the medium with Ta–Ru UL, high preheating results in a square hysteresis loop with negative nucleation field close to coercivity. Accompanying with this is the degraded So/Nm. It is unclear why coercivity decreases for the medium with Ta SL and being sputtered at high preheating substrate temperature. Table I summarizes the magnetic and recording properties of the media sputtered at different substrate temperature as well as with different SL and UL. Clearly, higher substrate temperature degrades the medium performance. The increased medium noise may be related to the excessive grain growth. It is worthwhile to mention that at low preheating, the medium

TABLE I
 H_c , SQ, AND So/NM FOR THE MEDIA SPUTTERED ON DIFFERENT UNDERLAYER AND AT DIFFERENT PREHEATING

UL	Pre-heating (°C)	Hc (Oe)	SQ	So/Nm (dB)
Ru	300	2540	0.7	24.0
	500	3462	0.84	19.4
Ta/Ru	300	3400	1	23.4
	500	2500	1	21.1

with Ta SL has higher perpendicular coercivity and better squareness. The So/Nm is not much affected by using Ta SL.

IV. CONCLUSION

We have studied the effects of SL and preheating on the crystallographic, magnetic and recording properties of CoCrPtB granular perpendicular magnetic media. Our results show that high preheating is not good for “quiet” perpendicular granular media. Amorphous Ta SL improved Co (0002) crystallography. High coercivity, unity squareness, and negative nucleation field are achieved even at low preheating without degrading signal-to-noise ratio. An improvement of UL and Co crystallography is a key in developing thermally stable, low-noise CoCrPtB PMR media.

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