CONTROLLING FePt GRAIN SIZE WITH A GRANULAR MgO-C INTERLAYER FOR HAMR

B. S. D. Ch. S. VARAPRASAD[1], B. ZHOU[1], T. MO[1], D. E. LAUGHLIN[1], and J.-G. (Jimmy) ZHU[1]

[1]Data Storage Systems Center, Carnegie Mellon University, Pittsburgh, PA, USA

INTRODUCTION

$L1_0$ FePt nano-hgranular media is uniquely positioned for heat assisted magnetic recording (HAMR) [1-3]. Currently (002) textured polycrystalline MgO is used as the underlayer for FePt to facilitate $L1_0$ ordering in perpendicular direction. Segregants like carbon or oxide or the mixtures of two have been used as to generate granular FePt microstructure [4-6]. Until now, the grain size of FePt is mainly controlled by the volume percentage of the segregant materials used during the deposition of the FePt layer. It is also known that the FePt grain grown across an MgO grain boundary of the underlayer could cause in-plane variants [6] and nucleation at the grain boundaries could result in (111) texture. In this paper, we present a systematic experimental investigation on developing a granular MgO-C interlayer deposited in between the MgO and FePt-X layers to control the FePt grainsize and distribution. We have experimentally demonstrated that FePt grain size and the corresponding microstructure in the FePt-C magnetic layer can be controlled by engineering the grain size and microstructure of the MgO-C interlayer.

EXPERIMENTAL RESULTS AND DISCUSSIONS

Experimental samples are fabricated on a naturally oxide surface of Si substrates with the following stack: MgO(10nm)/MgO-C(2)/FePt(0.2)/FePt-C(6). The MgO layer (referred to as underlayer), directly deposited at room temperature using RF sputtering with 50W sputtering power at 10mTorr Ar pressure. The MgO-C interlayer is deposited at room temperature using co-sputtering technique with RF sputtering for MgO and DC sputtering for C. The sputtering power is kept at RF100W for MgO and is varied for carbon deposition for various carbon concentrations. Interlayer deposition pressure has also been changed to optimize FePt-C layer grain size, microstructure and magnetic properties. After the deposition of MgO-C layer, the substrate temperature is raised to 600 ^{o}C. An approximately 0.2 nm thick FePt layer is then deposited on top of MgO-C interlayer using DC sputtering of 15W, followed by the deposition of FePt-C granular layer. For the FePt-C grainular layer, FePt and C are co-sputtered using DC with 20W and 300W sputtering power, respectively at 5 mTorr Ar pressure. The volume concentration of C in FePt-C layer is also varied in experiments. Modal experimental FePt-C media are also fabricated on (002) MgO single crystal substrate with the MgO-C (2nm) / FePt (0.2nm)/FePt-C (6nm) stack.

Figure 1 shows a TEM plan-view of a FePt-$C_{35vol\%}$ granular layer in which the volumetric percentage of carbon in the MgO-C interlayer is 40%. The micrograph shows that FePt grains are well separated by C grain-boundaries. The mean grain size of the FePt grains is 5.8 nm and the mean grain pitch is 7.8 nm. XRD analysis shows that the $L1_0$ order parameter of the FePt grain is S=0.79 with all correction factors considered [7]. Figure 2 shows the FePt grain sizes as a function of carbon concentration of the MgO-C interlayer while the carbon concentration of FePt-C layer is kept at 30% with the same deposition conditions (open

Bollapragada Varaprasad
sbollapr@andrew.cmu.edu

symbols). By solely varying the carbon concentrations in the MgO-C interlayer from 20% to 50%, the FePt grain size in the FePt-C layer changes from 11.5 nm to 6.5 nm. TEM study finds that the increase of carbon concentration in the MgO-C layer yields reduction of grain pitch of the MgO grains in the interlayer. The MgO grain pitch in the MgO-C layer is found to be similar to the FePt grain pitch of the FePt-C layer. The reduction of FePt grain pitch is well correlated with the reduction of FePt grain size, as shown in Fig. 3. All experimental results indicate FePt grains should have one-on-one growth on MgO grains in the MgO-C interlayer which also enables an additional means for controlling grain size and grain size distribution in the FePt-C magnetic layer. Correlations of in-plane ordered FePt grains as a function of MgO grain size of the MgO underlayer will be presented in the talk.

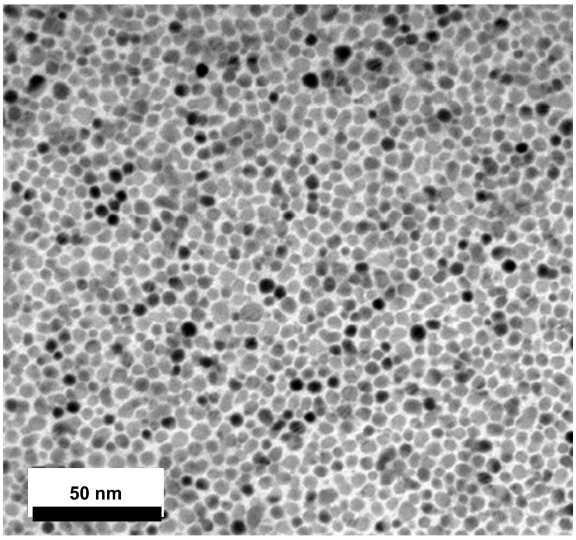

Figure 1. Plane-view transmission electron micrograph of granular FePt-$C_{35\%}$ layer of MgO(10)/MgO-C(2)/FePt(0.2)/FePt-C(6) film stack. The carbon volume percentage in the MgO-C inter layer is 40%. The average FePt grain size is 5.8 nm with average grain pitch of 7.8 nm.

1. D. Weller, A. Moser, L. Folks, M. E. Best, W. Lee, M. F. Toney, M. Schwickert, J. U. Thiele, and M. F. Doerner, IEEE Trans. Magn. 36, 10 (2000).
2. J.-U. Thiele, K. R. Coffey, M. F. Toney, J. A. Hedstrom, and A. J. Kellock, J. Appl. Phys. 91, 6595–6600 (2002).
3. A. Perumal, Y. K. Takahashi, T. O. Seki, and K. Hono, Appl. Phys. Lett. 92 132508 (2008).
4. T. Shiroyama, B. S. D. C. S. Varaprasad, Y. K. Takahashi, and K. Hono, IEEE Trans. Magn. 50(11) (2014).
5. Ram Acharya, Paper D3, The Magnetic Recording Conference, UC Berkeley, 2014.
6. H. Ho, J. Zhu, A. Kulovits, D. E. Laughlin, and J.-G. Zhu, J. Appl. Phys. 106, 193510 (2014).
7. E. Yang, D.E. Laughlin, and J.-G. Zhu, IEEE Trans. Mgn., vol. 48, No. 1, 7 (2012).

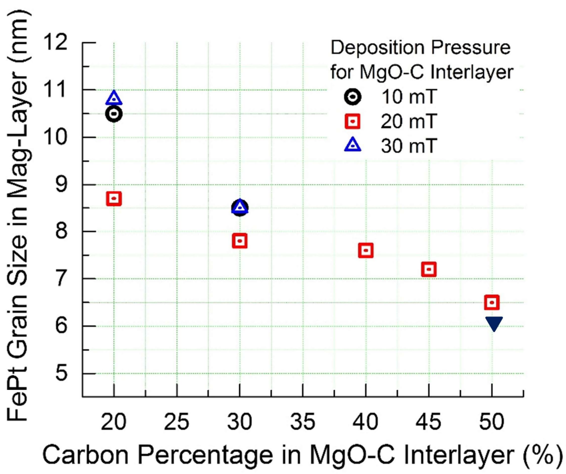

Figure 2. FePt grain size as a function of C-concentration in MgO-C layer. C-concentration in FePt-C layer is kept at 30% (open symbols) and 35% (the solid down-triangle symbol) cases, respectively.

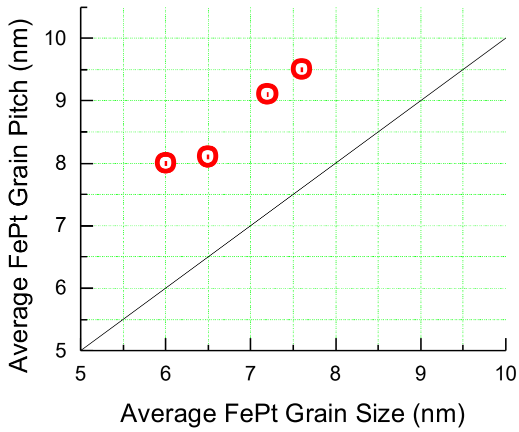

Figure 3. FePt grain pitch as a function of FePt grain size in the FePt-C granular magnetic layer.