5-8-2006

Magnetic Force Microscopy Study of CoPtCrO Perpendicular Media With Superparamagnetic And Permanent Magnet Tips

L. Yuan
University of Nebraska - Lincoln

Lei Gao
University of Kansas, lgao3@unl.edu

L. Nicholl
University of Nebraska - Lincoln

Sy-Hwang Liou
University of Nebraska-Lincoln, sliou@unl.edu

M. Zheng
MMC Technology, San Jose, CA, USA

See next page for additional authors

Magnetic Force Microscopy Study of CoPtCrO Perpendicular Media With Superparamagnetic And Permanent Magnet Tips

Yuan, L.
Gao, L.
Nicholl, L.
Liou, S. H.
Zheng, M.
Abarra, E. N.
Acharya, B. R.
Choe, G.
Malhotra, S. S.
Han, B.

Department of Physics & Astronomy, University of Nebraska-Lincoln, Lincoln, NE, USA

This paper appears in:

Magnetics Conference, 2006. INTERMAG 2006. IEEE International

Publication Date: 8-12 May 2006
Pages: 893 - 893
Location: San Diego, CA, USA
ISBN: 1-4244-1479-2
Digital Object Identifier: 10.1109/INTMAG.2006.374924
Posted online: 2007-06-25 10:09:23.0

Magnetic Force Microscopy Study of CoPtCrO Perpendicular Media With Superparamagnetic And Permanent Magnet Tips.

L. Yuan[1], L. Gao[1], L. Nicholl[1], S. H. Liou[1], M. Zheng[2], E. N. Abarra[2], B. R. Acharya[2], G. Choe[2], S. S. Malhotra[3] and B. Han[4]
1. Physics & Astronomy, University of Nebraska-Lincoln, Lincoln, NE, USA; 2. MMC Technology, San Jose, CA, USA; 3. Komag, San Jose, CA, USA; 4. State Key Laboratory of Magnetism, Institute of Physics, Chinese Academy of Science, Beijing, Beijing, China

Magnetic force microscopy (MFM) has been widely used in the study of magnetic recording media. It requires high resolution MFM tips as well as better understanding of the obtained magnetic images. In this study, we compared the images obtained by superparamagnetic and permanent MFM tips, that allows us to explain the issues related to the frequency double in some of domain images of the recording media. We also investigated the domain structures of high density recording bits (up to 1100 kfci) written on ac and dc-erased CoPtCrO perpendicular magnetic recording (PMR) media with permanent magnet MFM tips under ambient conditions.

As shown in Fig. 1, we compared the magnetic (phase) image of the 200 kfci track in an ac-erased area taking with a permanent and a superparamagnetic tip. Fig. 1a is the image obtained by the permanent magnet MFM tip, that shows a dominate spectral frequency of about 200 kfci. Fig. 1b is the image taken by a superparamagnetic tip, that shows a dominate spectral frequency of about 400 kfci. This clearly demostrated that the frequency doubling were observed by using a superparamagnetic tip. This may explain the observation of the frequency doubling by Zhifeng Deng et. al [1] in their phase images of a PMR medium using metal-coated carbon nanotube tips. We show that the magnetic images obtained by different types of MFM tips can provide valuable magnetic information about the sample.

PMR has been demonstrated as a promising technology to sustain continuous growth in data storage capacity compared to longitudinal magnetic recording media. Two preconditioning techniques, ac and dc-erasure, can be performed before recording tracks on the medium. In this study, we investigated the domain structures of high density recording bits written on ac and dc-erased CoPtCrO PMR media with our permanent magnet MFM tips.

Fig. 2a shows the domain images of recording tracks with linear recording densities of 900 and 1100 kfci written after ac-erasure. Tracks of 900 and 1100 kfci correspond to bit sizes of 28 and 23 nm, respectively. The MFM images of the 900 kfci tracks present well-resolved recording bits. The 1100 kfci transitions are more difficult to discern due to the strong background. Fig. 2b shows the domain images of recording tracks with linear recording densities of 900 and 1100 kfci written after dc-erasure. The bits corresponding to 900 kfci are clearly visible. Some 1100 kfci bits are observable but are modulated by the magnetic clusters. In order to get a more quantitative analysis of the tracks, we have performed a Fourier transform to get the power spectrum of the digitized profile. Fig. 3a shows the power spectra of the 900 and 1100 kfci tracks written after ac-erasure. The peaks correspond to the recorded signal. Fig. 3b shows the averaged power spectra for tracks recorded after dc-erasure. Comparing the Fourier spectra, the peak for 1100 kfci written after ac-erasure has a larger amplitude than written after dc-erasure. Since the peaks are from the periodic properties of the recording bits, this indicates the periodicity of the transition bits for 1100 kfci after ac-erasure are better than after dc-erasure in this medium.

In summary, we show that the magnetic transition of 1100 kfci density can be identified with our permanent magnet tips. These permanent magnet tips can be used to resolve magnetic features smaller than 25 nm in ambient conditions. To study of magnetic images, using more than one type of tips may help in the quantitative analysis of MFM data. [1] Zhifeng Deng, Erhan Yenilmez, Josh Leu, J. E. Hoffman, Eric W. J. Straver, Hongjie Dai, and Kathryn A. Moler, Appl. Phys. Lett., 85, 6263 (2004).

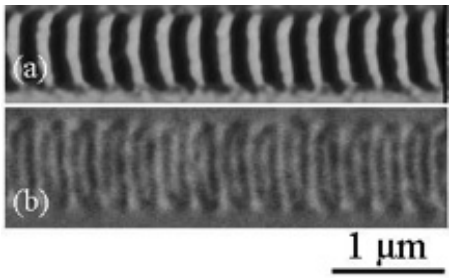

Fig. 1 Magnetic (phase) images of the 200 kfci track in an ac-erased area taking with (a) a permanent magnetic tip and (b) a superparamagnetic tip.

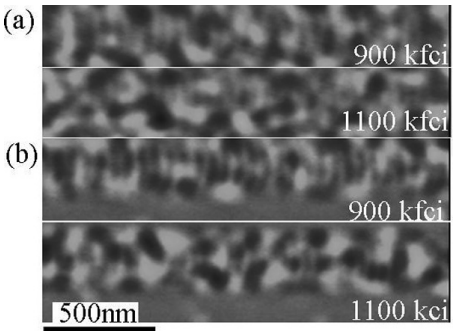

Fig.2 MFM images of recording tracks with linear densities of 900 and 1100 kfci written on (a) an ac-erased and (b) a dc-erased CoPtCrO perpendicular medium.

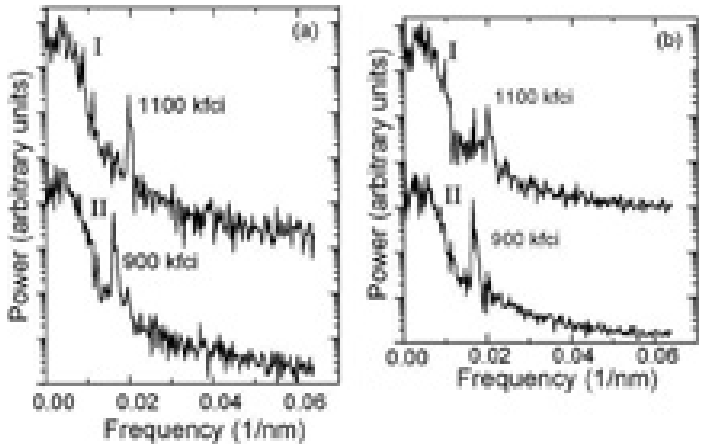

Fig. 3 Fast Fourier transform power spectra of the along-track profile for tracks written after (a) ac-erasure and (b) dc-erasure for the track densities of (I) 1100 kfci and (II) 900 kfci.