Issues and Prospects of Perpendicular Magnetic Recording

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About 25 years have passed since perpendicular magnetic recording (PMR), in which a double layered medium backed by a soft magnetic under-layer (SUL) is combined with a single-pole head, was first proposed [1]. Finally, Hard Disk Drives (HDD) adopting PMR will be shipped very shortly. In addition, the R&D aiming at 1 Tbit/inch^2 is also promoted by PMR. This report will describe the potential of PMR, the issues for practical use and the prospects for the future.

At the beginning of the research into PMR, it was difficult to quantitatively explain the superiority of PMR to longitudinal magnetic recording (LMR). Because of that, several misunderstandings arose about the potential of PMR. In 1999, a quantitative method of analyzing transition parameters was introduced [2], which is able to calculate the media parameters with a PC for high density recording in both PMR and LMR (Fig.1). From the analysis, we can show that the width of a magnetization transition in PMR decreases to the thickness of the grain boundary in a medium with a narrow grain coercive force distribution on increasing the thickness of the recording layer and the field gradient of the write head. Therefore it is a requirement of the recording layer of a medium that the grain size should be kept small to decrease jitter noise. The grains should also have a high anisotropy constant K_u for high thermal stability. Recently, CoPtCr-SiO_2 films having K_u of about 4 x 10^6 [erg/cc], which is twice that of CoCrPt films, have been developed as one of the candidate recording layers for the practical use of PMR (Fig.2) [3], and high areal density recording of about 150 Gbit/inch^2 was demonstrated by using such media.

Although the development of read heads with a higher sensitivity and a higher resolution is still continuing, the development of single-pole type write heads having a stronger and steeper perpendicular field is lagging behind. The magnetic field distribution of a single-pole head is sensitive to the geometrical structure of the head-medium system [4], because of the magneto-static interaction between them. Moreover, to improve the write efficiency of a single-pole, the main-pole should be energized as near to the tip as possible. Designs taking these points into account will remarkably improve the write performance of the single-pole head [5]. The curvature of bits along the cross-track direction and track smearing in the down-track direction are also big issues in PMR. To avoid these, discrete track technologies are also discussed.

By such continuous efforts, 1 Tb/inch^2 recording should be achieved in PMR and a recording capacity of more than 60 GB is expected even in a 1 inch diameter disk. Such a small size HDD possessing such a high capacity could be applied to mobile audio-video systems, ITS systems, electronic medical record systems and so on, as a ubiquitous storage system (Fig. 3) in the near future.

[References] 1. S. Iwasaki, at al., *IEEE Trans. Magn.*, **MAG-14**, pp.436, (1978). 2. Y. Nakamura, *IEICE Trans. Electro.*, **E85-C**, pp.1724, (2002). 3. S. Takenoiri, et al., *J. Magn. Soc. Jpn.*, (in Japanese), **27**, pp.940, (2003). 4. Y. Nakamura, at al., *IEEE Trans. Magn.*, MAG-22, pp.376, (1986). 5. H. Muraoka, et al., *IEEE Trans. Magn.*, 35, pp.643, (1999).

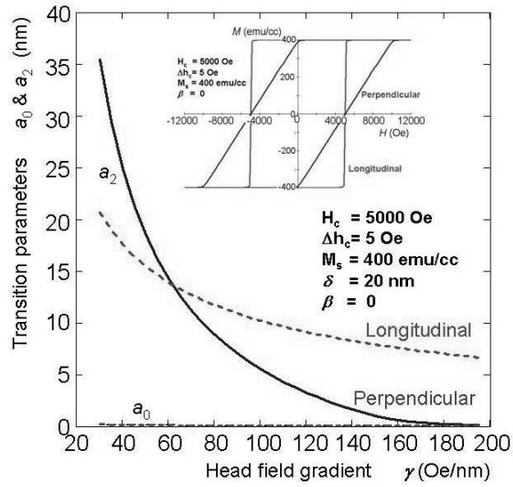

Fig. 1 A comparison of transition parameters in PMR and LMR, estimated by an analytical method.

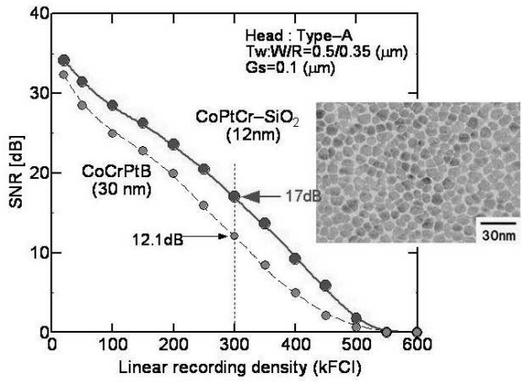

Fig. 2 Improvement of SNR in a PMR disk upon depositing CoCrPt-SiO_2.

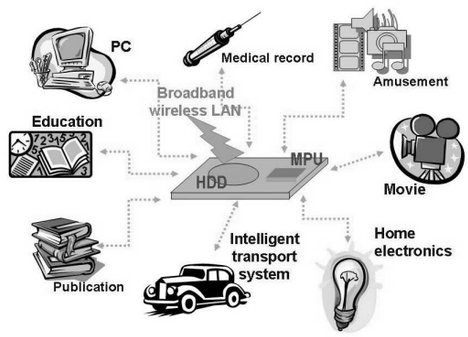

Fig. 3 Image of a ubiquitous storage system using small size and high capacity HDD.