Available online at www.sciencedirect.com

SCIENCE DIRECT®

Journal of Magnetism and Magnetic Materials 287 (2005) 459–467

Journal of magnetism and magnetic materials

www.elsevier.com/locate/jmmm

Perpendicular integration challenges

Davide Guarisco*, Yan Wu, Peng Luo, Bill E. Higgins, Kaz Saito

Maxtor Corporation, 500 McCarthy Blvd., Milpitas, CA 95035, USA

Abstract

This paper discusses progress and challenges of integrating high areal density perpendicular recording components into a hard disk drive. Selected head and media, as well as system-level, issues are investigated.

PACS: 85.70.Li; 85.70.Kh; 85.70.Ec; 75.50.Ss

Keywords: Perpendicular magnetic recording; Recording systems; Perpendicular recording heads; Perpendicular recording media

---

1. Introduction

In recent areal density demonstrations perpendicular recording (PMR) has surpassed longitudinal recording (LMR) [1a,b]. This progress is due to improved heads and media, which have been developed in the last two years. In theory perpendicular recording compares favorably with longitudinal recording. Because of the larger write field achievable with PMR, media with higher coercivity can be used, improving thermal stability at smaller grain sizes and pushing the superparamagnetic limit further out. Also, the amplitude of the readback signal is higher, as more flux is collected by the read sensor. Now these theoretical advantages have come to fruition, and commercialization of PMR systems appears likely in the near future. However, while PMR components have made significant progress, several serious head/media, as well as system integration challenges remain [2a,b]. This paper discusses advances in heads/media and some integration issues and possible solutions. Other important integration topics, such as servo systems and channels, are not discussed here, as they are outside the scope of the paper.

2. Heads

2.1. Monopole vs. shielded-pole heads

The concept of “*shielded-pole*” or *narrow-gap* heads has been introduced by Mike Mallary et al. [3] and is illustrated in Fig. 1. A comparison of the

---

*Corresponding author. Tel.: +1 408 894 5489; fax: +1 408 894 5313.

E-mail address: davide_guarisco@maxtor.com (D. Guarisco).

doi:10.1016/j.jmmm.2004.10.076

vertical and longitudinal write fields for a monopole and shielded-pole head is shown in Fig. 2. It is clear that while the value of the vertical field is smaller for the shielded-pole head, a significant longitudinal field component contributes to the Stoner–Wohlfarth effective write field and results in increased writability for a properly dimensioned write gap. Also, the field gradient is sharper for the shielded-pole head, allowing for sharper transitions and higher linear density.

This theoretical advantage of shielded-pole heads is verified in practice. Fig. 3 shows a measurement of bit error rate (BER) vs. linear density ("BPI push") for two heads of similar magnetic writer width (MWW = 210 nm) on the same media. The measurements were performed at 5400 RPM at the ID of a 95 mm disk, where the skew angle was −8.6°. Each point is the average of 20 writes. The media used was a granular oxide media with a soft underlayer (SUL). An increase in linear density of ~ 30% was observed with the shielded-pole head.

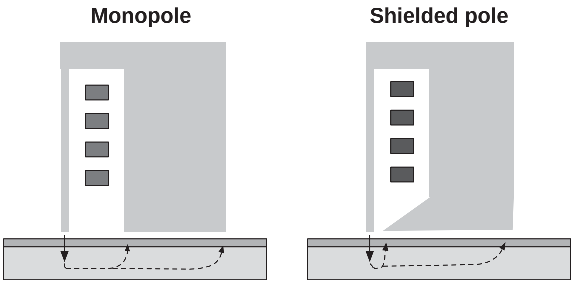

Fig. 1. Schematic illustration of monopole and shielded-pole PMR heads.

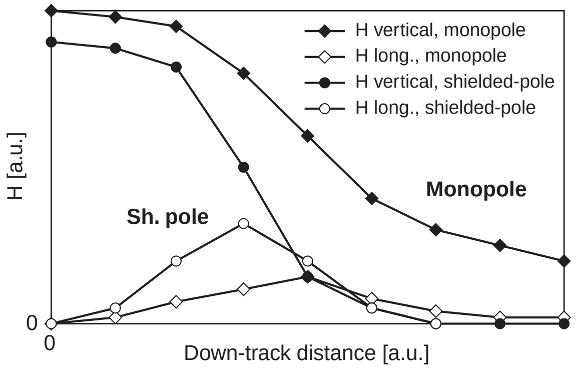

Fig. 2. Schematic plot of the vertical and longitudinal write fields for a monopole and a shielded-pole head. The origin of the abscissa corresponds to the center of the main write pole.

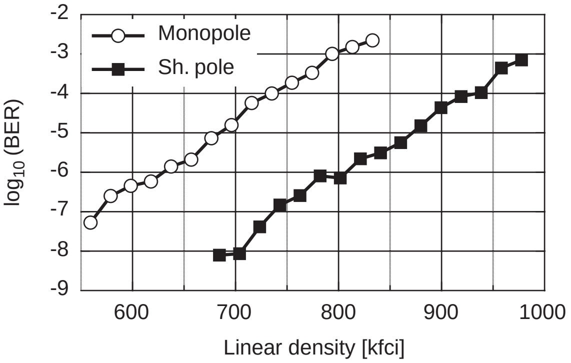

Fig. 3. BPI push plot comparing a single-pole with a shielded-pole head on the same media.

2.2. Narrower MRW

It has been shown before [4] that the same reader results in a narrower magnetic reader width (MRW) on PMR media than on LMR media. For this experiment, we used two groups of five perp. and long. heads on five different types of media: A series of PMR disks with varying SUL thickness, including one disk without SUL, and a conventional LMR disk. The recording layers of the PMR disks were very similar, with coercivity $H_c = (4300 \pm 100)$ Oe and nucleation field $H_n = -(2000 \pm 100)$ Oe. Microtracks were measured for all head/media combinations at the MD radius (where the skew angle is zero) in the following way. First, an AC band-erase operation is carried out around the center track over a region wide enough (~ 6 μm) to exclude any net flux being picked up by the reader. Second, a low-frequency signal is written (linear density 88 kfci) and its amplitude is measured using a narrow-band filter. Third, two side tracks at a given offset are DC-erased (DC-erase gives the sharpest and cleanest microtracks). Fourth, the microtrack profile is recorded with a narrow-band filter. This procedure is repeated for varying side track offsets until the max. amplitude of the microtrack profile is $(13 \pm 2)\%$ of the full track amplitude. Four representative microtracks are shown in Fig. 4. Here we