HAMR ADC CMR and SMR with MSMR-2R/3R Gain: Linear Density vs Trackpitch

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HAMR areal density demonstrations for both CMR and SMR are presented with MSMR, a subset of TDMR where readers are reading from a single track of interest. The MSMR gain was taken in both linear density and trackpitch. HAMR CMR tracks preferred to take the MSMR gain in linear density to maximize areal density capacity whereas HAMR SMR tracks preferred to take the MSMR gain in trackpitch. At spinstand, 3700 Gfpsi areal density demonstration, equating to over 6.5 TB/disk, has been achieved with HAMR SMR when combined with 2 Reader MSMR.

Index Terms— Heat Assisted Magnetic Recording (HAMR), Conventional Magnetic Recording (CMR), Shingled Magnetic Recording (SMR), Multiple Sensor Magnetic Recording (MSMR), Two Dimensional Magnetic Recording (TDMR), Areal Density Capacity (ADC)

I. Introduction

Heat Assisted Magnetic Recording (HAMR) has proven to be the primary successor to perpendicular magnetic recording providing continued and significant growth in areal density [1]. There are two current productized write architectures for the layout of tracks in HAMR hard disk drives: Conventional Magnetic Recording (CMR) and Shingled Magnetic Recording (SMR). In CMR, any track can be written at any time and neighboring tracks do not intentionally overlap. In SMR, the tracks are written sequentially in bands with the tracks intentionally overlap like shingles on a roof [2]. The read-back architecture Multiple Sensor Magnetic Recording (MSMR) can be combined with the two different write architectures to increase areal density [3, 4] by using two or more readers and/or multiple spins to read-back the same track. Previously, the MSMR gain was taken in linear density [4]. In this paper, we compare the areal density capability (ADC) of HAMR CMR and HAMR SMR with read-back with one reader (1R), MSMR with 2 readers (MSMR-2R) and MSMR with 3 readers (MSMR-3R) taking the MSMR gain in linear density and trackpitch.

II. Spinstand Experimental Details

We investigated the ADC for HAMR CMR and SMR with 1R, MSMR-2R and MSMR-3R on the spinstand with 6x adjacent track writes for CMR and 1x adjacent track write for SMR. The ADC demo criteria had additional margin for adjacent track interference with a tighter requirement than the ASTC areal density metric [5]. For this study, eleven integrated HAMR heads were measured on HAMR media. The HAMR heads and media were similar in design to those used in the previous study [6].

Spinstand measurements were at radius of 29 mm, skew 0° and 7200 rpm with linear velocity of ~22 m/s. Writer and reader clearances were maintained at 1 nm and compensated for changes in writer and laser protrusions. Channel areal density (Gfpsi) was measured and the channel code rate was similar to the previous studies [3-6]. The MSMR gain with 2-3 readers was calculated with multiple spin captured waveforms from the spinstand with the native HAMR reader processed by MSMR 2 and 3 reader software channel.

III. Results

The spinstand results of the MSMR-2R linear density gain and trackpitch improvement for HAMR CMR and SMR are shown in Fig. 1. For the CMR tracks, the MSMR-2R gain preferred linear density (3.9% ADC gain) to trackpitch improvement (3.1% ADC gain) to maximize ADC. For the SMR tracks, the MSMR-2R gain preferred trackpitch improvement (4.5% ADC gain) to linear density (3.7% ADC gain) to maximize ADC.

The MSMR-3R linear density gain and trackpitch improvement for HAMR CMR and SMR are shown in Fig. 2. For the CMR tracks, the MSMR-3R gain preferred linear density (5.9% ADC gain) to trackpitch improvement (4.8% ADC gain) to maximize ADC. For the SMR tracks, the MSMR-3R gain preferred trackpitch improvement (7.4% ADC gain) to linear density (6.0% ADC gain) to maximize ADC.

For both MSMR-2R and MSMR-3R, HAMR CMR tracks preferred to take the MSMR gain in linear density to maximize ADC whereas HAMR SMR tracks preferred to the MSMR gain in trackpitch. The preference for MSMR gain for linear density or trackwidth is due to the physics of CMR double sided adjacent track interference compared with SMR single sided adjacent track interference.

The ADC of HAMR CMR and SMR with 1R, MSMR-2R and MSMR-3R with the MSMR gain taken in linear density and trackpitch are shown in Fig. 3.

Spinstand high ADC demonstrations using HAMR CMR and HAMR SMR are shown in Fig. 4 and Fig. 5. The highest HAMR ADC record of 3700 Gfpsi with state-of-art HAMR heads and media are shown. The estimated capacity per disk for this ADC demonstration was 6.5 TB/disk based on expected format efficiency. This ADC demonstration used HAMR SMR with MSMR-2R gain taken in trackpitch. The spinstand demonstration represents what is possible in a recording system and that there are no fundamental physic barriers to achieving over 3500 Gfpsi or 6 TB/disk with HAMR technology.

IV. Conclusion

HAMR areal density demonstrations for both CMR and SMR are presented with MSMR. The MSMR gain was taken in both linear density and trackpitch. HAMR CMR tracks preferred to take the MSMR gain in linear density to maximize areal density capacity whereas HAMR SMR tracks preferred to take the MSMR gain in trackpitch. At spinstand, 3700 Gfpsi areal density demonstration, equating to over 6.5 TB\disk, has been achieved with HAMR SMR with MSMR-2R with MSMR gain taken in trackpitch. These experiments help to establish the intrinsic scalability of HAMR with significant and continued growth in areal density.

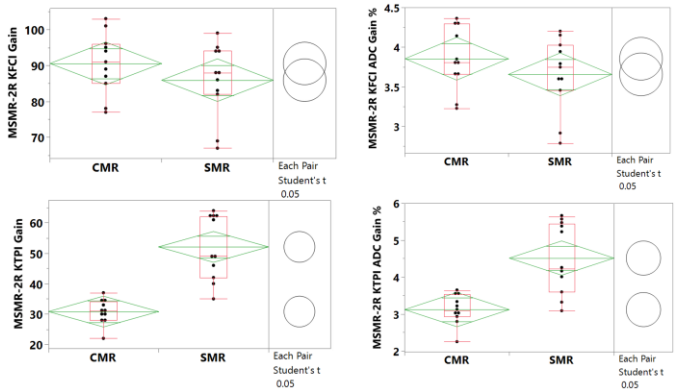

Fig. 1. Spinstand Results of the MSMR-2R Linear Density Gain and Trackpitch Improvement for HAMR CMR and SMR

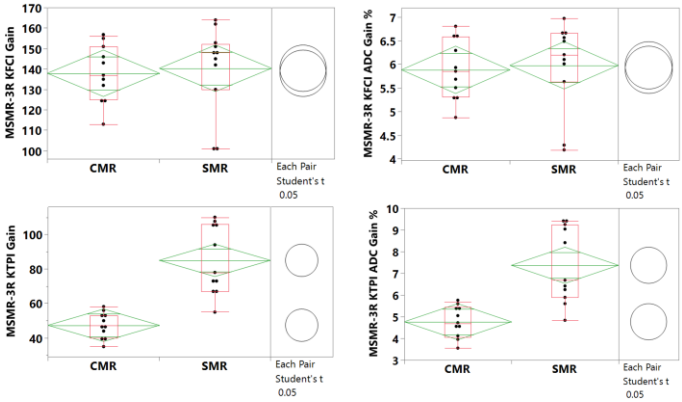

Fig. 2. Spinstand Results of the MSMR-3R Linear Density Gain and Trackpitch Improvement for HAMR CMR and SMR

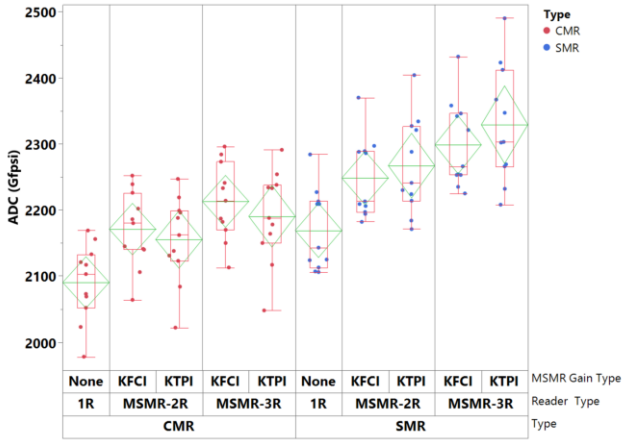

Fig. 3. Areal Density Capability of HAMR CMR and SMR with MSMR-2R and MSMR-3R Gain taken in Linear Density and Trackpitch

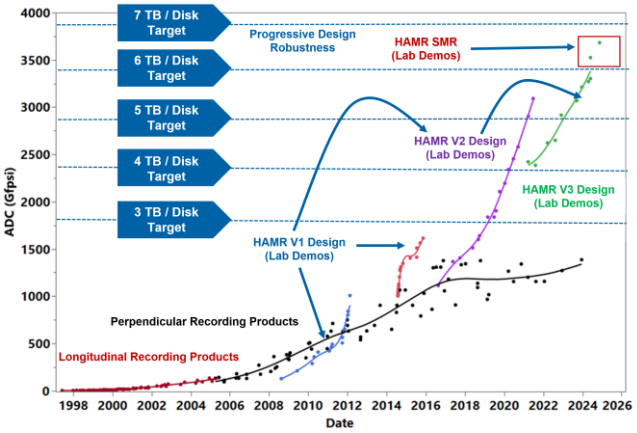

Fig. 4. Areal Density Capability over time for Seagate Longitudinal Recording Products, Perpendicular Recording Products and HAMR Spinstand Demonstrations

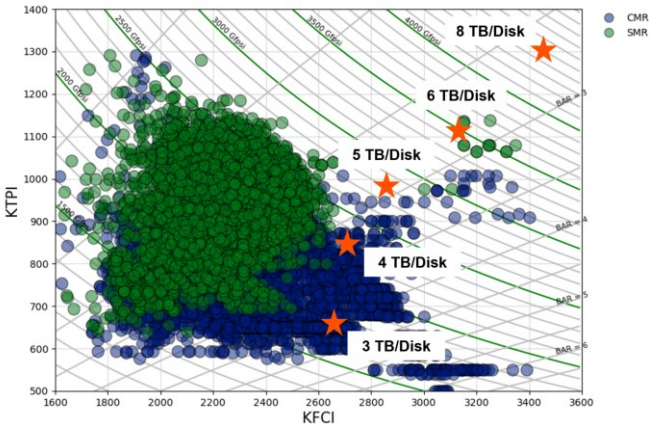

Fig. 5. HAMR Areal Density Capability Demonstrations using HAMR CMR and SMR

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