HEAT ASSISTED INTERLACED MAGNETIC RECORDING

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I. INTRODUCTION

Heat Assisted Magnetic Recording (HAMR) is the next generation hard disk drive technology which enables continued and significant areal density growth [1]. There are currently two common architectures for the layout of tracks in 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. In this paper, we introduce a novel track layout, Interlaced Magnetic Recording (IMR)[2] and apply it with a HAMR recording system.

II. HEAT INTERLACED MAGNETIC RECORDING

Heat Interlaced Assisted Magnetic Recording (HIMR) is an alternative recording architecture where tracks are recorded in an interlaced order with different linear densities. In IMR, there are two different types of tracks: bottom and top tracks. Bottom tracks are written first at every other track location whereas top tracks are written second at every other track at an offset as seen in Figure 1. IMR is convenient with HAMR since the linear density can be adjusted based on the linear density tradeoff with laser current. Bottom tracks can be written wide with a higher laser power and top tracks can be written narrow with a lower laser power. Bottom tracks are double sided squeezed by the top tracks whereas top tracks are non-squeezed. Since the top tracks squeeze the bottom tracks, the top track laser current defines the trackpitch of the HIMR system. HIMR ADC gain is from three main sources: bottom track linear density gain from increased laser current (which reduces curvature and increases the thermal gradient), top track linear density gain from non-squeezed conditions (top tracks do not suffer from adjacent track write interference since the next top track is two tracks away) and trackpitch is defined by the top track laser current which is lower and gives a narrow track enabling high kTPI. IMR has one system performance penalty. Top tracks can be re-written as many times as needed but to overwrite a bottom track with top tracks present, the adjacent top tracks need to be read and then re-written after the bottom track. A band structured like with SMR may be desired but the system performance penalty for IMR will be similar or less than SMR depending on the workload of the drive.

II. EXPERIMENTAL DETAILS

We investigated the areal density capability for HAMR, HAMR SMR and HIMR on a spinstand using the ASTC areal density metric [3]. Ten HAMR heads were used. The heads and media were similar to those used in previous studies [3-4]. Spinstand measurements were with writer current 55mA, active reader and writer clearance of 1 nm, radius of 23 mm, skew 0^{o} and 5400 rpm with linear velocity of 13.21 m/s. Channel areal density (Tflux/in^2) was measured. A code rate of 0.88 was used to calculate user areal density (Tbit/in^2).

III. RESULTS

The areal density capability of the ten HAMR heads yielded an average HAMR ADC of 1.15 Tbit/in^2 with 32x adjacent track writes, HAMR SMR ADC of 1.46 Tbit/in^2 and HIMR ADC of 1.5 Tbit/in^2 as seen in Figure 2a. HIMR observed a 31% increase in areal density over HAMR whereas HAMR SMR observed a 27% increase in areal density over HAMR. For HAMR, HAMR SMR and HIMR, the bit aspect ratio was measured as seen in Figure 2b. For HAMR SMR and HIMR, the track density was significantly higher than HAMR due to the single adjacent track write. HAMR SMR had the highest track density because of the single-sided adjacent track interference (ATI) when shingling the tracks. For HIMR, the linear density and bit aspect ratio was significantly higher than HAMR and HAMR SMR due to the increase in laser current for the

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IMR bottom tracks and the adjacent track interference reduction for top tracks.

It should be noted that the best components from this design at a more aggressive clearance achieved a channel density around 2 Tbit/in^2 when combined with SMR and MSMR (Multiple Sensor Magnetic Recording).

IV. CONCLUSION

This novel interlaced track layout architecture enables further increases in HAMR areal density capability (HIMR) which is favorable for the hard disk drive markets with a system performance penalty less than shingled magnetic recording.

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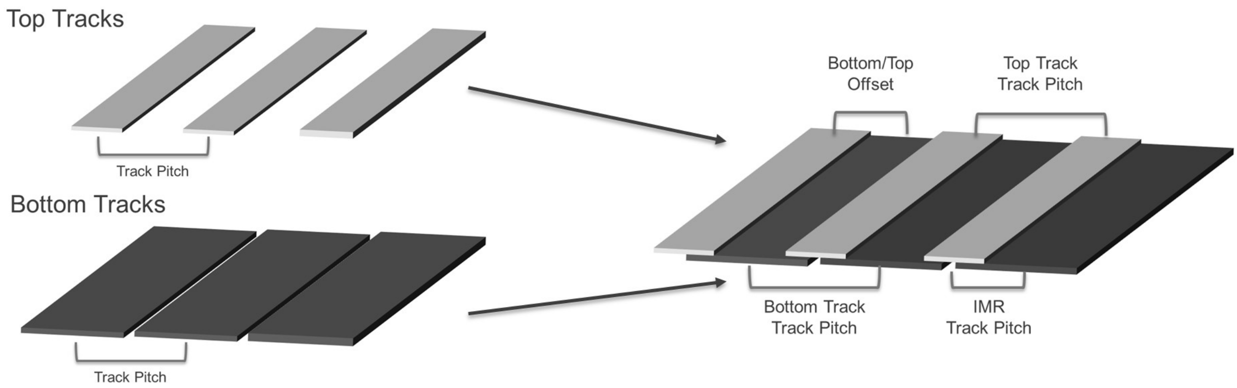

Figure 1: Heat Assisted Interlaced Magnetic Recording Track Layout

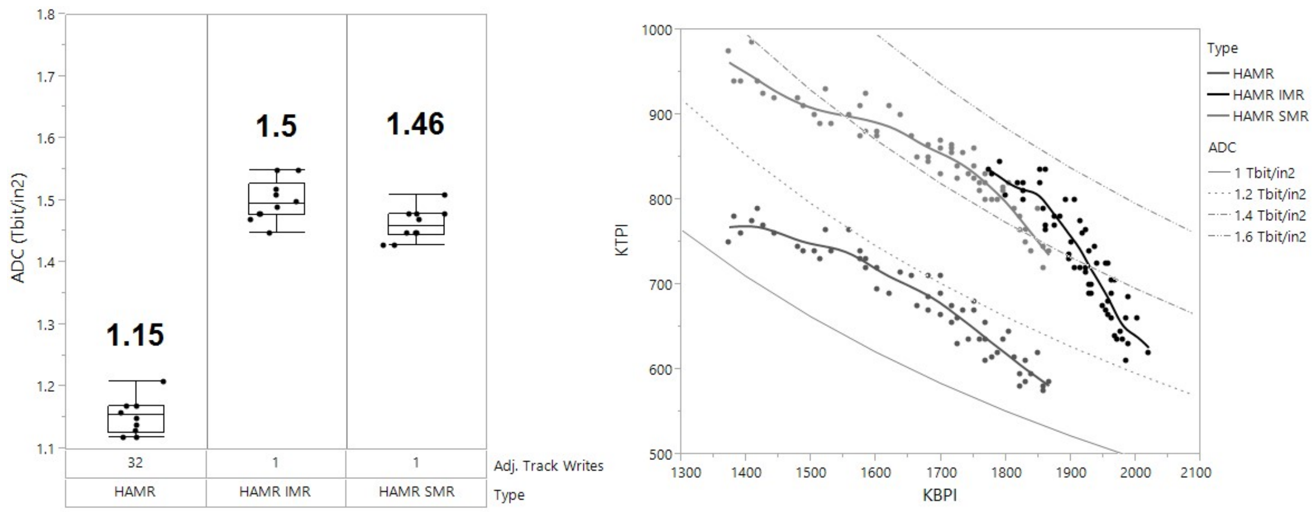

Figure 2: HAMR, HAMR SMR and HIMR: ASTC ADC and VBAR