ATI CONSIDERATIONS IN HELIUM-FILLED HARD DISK DRIVES

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I. INTRODUCTION

All hard disk drive (HDD) manufacturers are now shipping HDDs with sealed enclosures containing helium. Compared with conventional air-filled HDDs, helium-filled enclosures exhibit significantly reduced turbulence and therefore reduced mechanical vibrations. This provides many benefits: the power required to spin the platters is reduced, a larger number of thinner platters can be built into devices with the same stack height, while also achieving significantly improved tracking capabilities. The improved tracking capabilities and the consequences for the recording system are our focus here.

Margins against track mis-registration (TMR) and adjacent track interference (ATI) have long been a consideration when designing the recording system [1]. HDDs targeted for the "capacity enterprise" market segment have stringent performance requirements which, until recently, have favored recording systems more limited by TMR than by ATI. In a simplified sense: if the recording system achieved the target capacity based on TMR requirements, the ATI effects could be managed with HDD system features (background refresh, etc.).

The continued development and improvement of enclosures and tracking features in helium-filled HDDs have led to further reductions in TMR margins which result in an inversion of the TMR/ATI relationship. In our experiment below we demonstrate that, for future helium-filled HDDs, the capabilities of the system management features to guard against ATI are now the main limitation when assessing candidate components with a spinstand areal density (AD) measurement.

II. EXPERIMENT

To investigate the mechanisms limiting areal density, we performed spinstand measurements over a wide range of TMR margins and number of adjacent track writes on each side, following the techniques described in [2]. Additionally, we also measured with the *ASTC AD conditions* as described in [1]. For both AD measurement methods, we explore the kbpi/ktpi space to find the optimum based on the required set of test conditions (TMR, ATI, writing parameters, clearance, etc.).

Single reader recording heads of similar design to those used in current products were tested using experimental recording media with an exchange-coupled-composite (ECC) design [3]. Nominal track density for these recording heads is approximately 450 ktpi. Test conditions are typical of capacity enterprise products: 7200 rpm, 0° skew and ~22 m/s linear velocity.

III. RESULTS

Figure 1 summarizes our results for conventional magnetic recording (CMR), i.e.: recording systems where individual tracks are expected to be written randomly. We plot contours of normalized AD as a function of, normalized TMR margin on the x-axis, and adjacent track writes on the logarithmic y-axis. Annotations indicate that air-filled products are limited to the region of higher TMR margin, whereas the lower TMR margin part of the chart is expected to be reached by future He-filled products.

Beginning at high normalized TMR margin (100), the contours of normalized AD are broadly vertical, indicating that the TMR margin is the only limit on AD. As the TMR requirement is reduced, the contours exhibit greater curvature indicating the progressively stronger effect of ATI. We interpret this as the reduction in TMR margin progressively revealing the cross-track fringing of the effective field of the recording system [4, 5].

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IV. CONCLUSION

Further increasing the track density of recording systems for future products requires that the cross-track effective field be engineered to again be largely contained within the mechanical TMR margin. In the short term for CMR, further refinements of ECC media structures and write head design will we required. In the longer term, alternative recording technologies [6, 7] must show significantly improved effective cross-track recording gradients to further grow areal density. Mitigation of the effects of ATI will be one method among many to continue to increase the capacity of HDDs.

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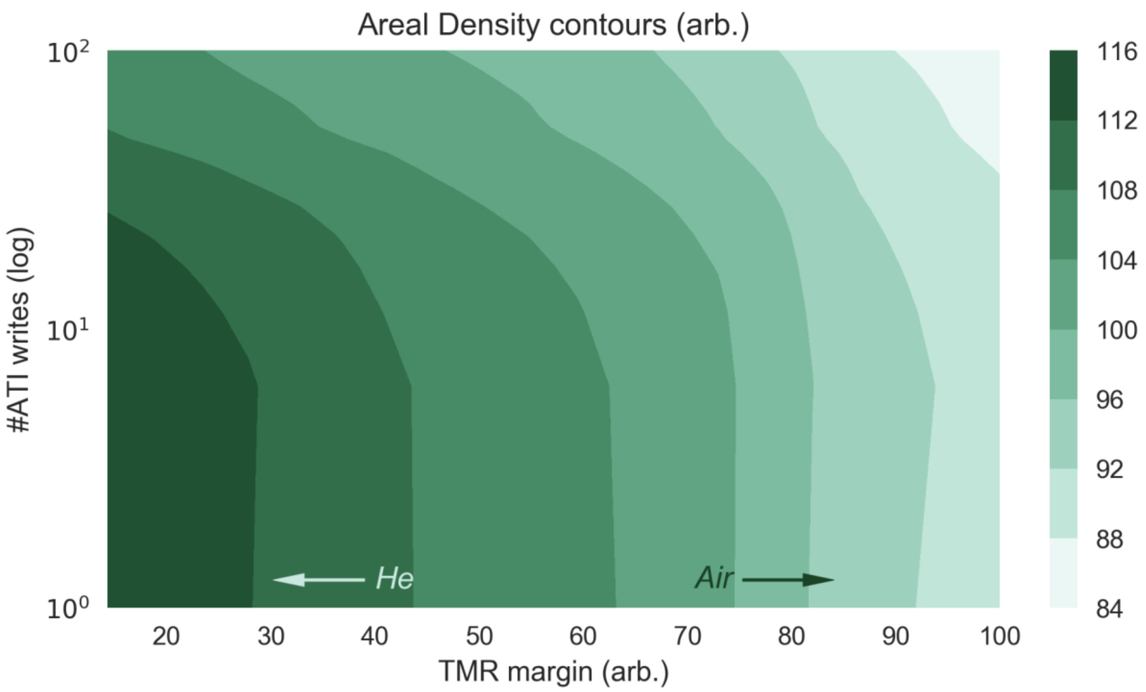

Figure 1: Typical margins for air-filled HDDs require high TMR margins. Future He-filled products are expected to occupy the lower TMR margin regions where ATI dominates.