Shingled Magnetic Recording Using HAMR Technology

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Recently, two primary writing architectures have been employed in magnetic hard disk drive (HDD) storage devices: conventional magnetic recording (CMR) and shingled magnetic recording (SMR). SMR offers higher areal density capability (ADC) compared to CMR, although it compromises random write/read performance. On the other hand, two main writing process is applied to hard disk drive, which are heat assisted magnetic recording (HAMR) and flux control microwave assisted magnetic recording (FC-MAMR). This two writing process is completely different each other, but HAMR method can obtain higher ADC rather than that of MAMR technology. In this work, we compared ADC gain from CMR to SMR using FC-MAMR and HAMR drives. ADC gain is almost comparable between FC-MAMR and HAMR in our design. Therefore, we can obtain highest capacity using HAMR SMR drive.

***Index Terms*— Heat-assisted Magnetic Recording (HAMR), Microwave-assisted magnetic recording (MAMR), Perpendicular magnetic recording (PMR), Shingled magnetic recording (SMR)**

I. Introduction

Hard disk Drives (HDD) achieve high areal density with various technology such as perpendicular magnetic recording[1]-[2], giant magnetoresistive junction[3]-[4], tunnel magentoresistive junction[5]-[6], shingled magnetic recording (SMR)[7]-[8], flux control microwave-assisted magnetic recording (FC-MAMR)[9] and heat-assisted magnetic recording (HAMR)[10]. The market primarily utilizes two writing schemes: conventional magnetic recording (CMR) and SMR. SMR method is suppressed random performance but higher areal density rather than CMR method. FC-MAMR and HAMR are completely different writing principle. Magnetic field between write gap and to recording media can be controlled using FC-MAMR. On the other hand, HAMR technology can control temperature of media using laser diode. FC-MAMR drives are mainly used in the latest market but HAMR is expected as higher capacity of next generation. In the following sentence, FC-MAMR will simply be referred to as MAMR.

Higher tracks per inch (TPI) is obtained from HAMR rather than MAMR architecture, because bit aspect can be defined heat spot size from laser diode. Therefore, we can obtain higher areal density capability with optimized laser conditions. In this study, we compared some SMR properties with MAMR and HAMR technology.

II. HDD Experiment

In order to investigate difference between MAMR and HAMR on SMR scheme, we compared some properties using HDD drives. HDD has 7200 rpm of rotation speed. Skew angle is around 17 deg. at outer diameter (OD) side and -17 deg. at inner diameter (ID) side, respectively. We evaluated bit error rate of write pattern both on-track and after erase at adjacent track. Then, we calculated maximum areal density capability with each condition of CMR and SMR using MAMR and HAMR drives.

III. Results and Discussion

First, we compared switching properties of SMR write direction. The switching properties were defined by comparing adjacent track interference of IDtoOD and ODtoID direction, respectively. Fig.1 shows maximum write offset value dependency on each radius position with SMR write direction using MAMR drive. In OD area, maximum write offset value of ODtoID direction is larger than that of IDtoOD direction. On the other hand, IDtoOD direction is higher than ODtoID direction in ID area. Both properties are overlapping around 9 of radius, which is defined as switching position of SMR write direction. Fig.2 shows also HAMR case. Maximum write offset dependency shows same tendency on MAMR.

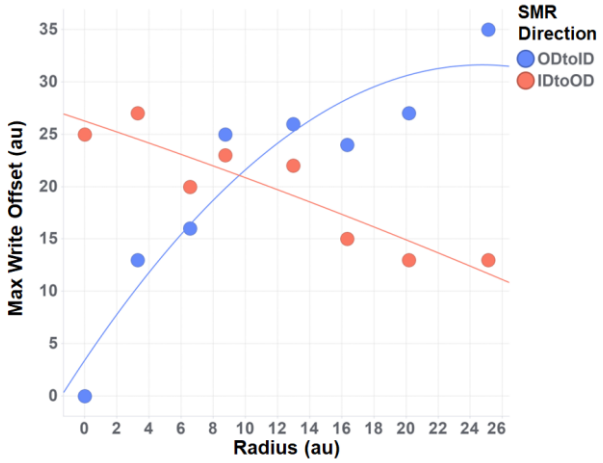

Fig. 1. Max write offset as a function of radius on MAMR drive.

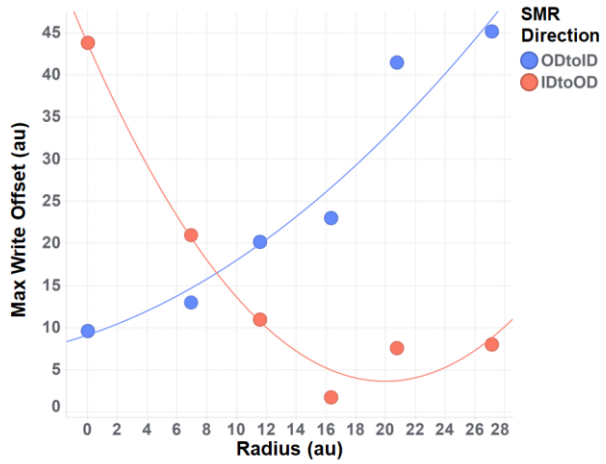

Fig. 2. Max write offset as a function of radius on HAMR drive.

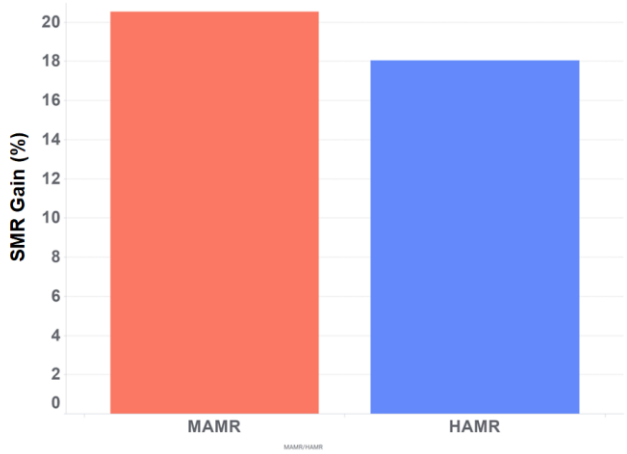

Fig. 4. Comparison of SMR gain between MAMR and HAMR drives.

Fig.3 illustrates the distribution of switching positions for MAMR and HAMR. In the case of MAMR, the average switching position is approximately 10, which corresponds closely to a skew angle of 0 degrees on the drive. of skew angle on the drive. On the other hand, switching position of HAMR drives is shifted to inner side around 9. Moreover, standard deviation of HAMR is larger than that of MAMR, which suggests that cross track thermal/magnetic field properties are almost same between OD and ID side and less dependent on skew angle.

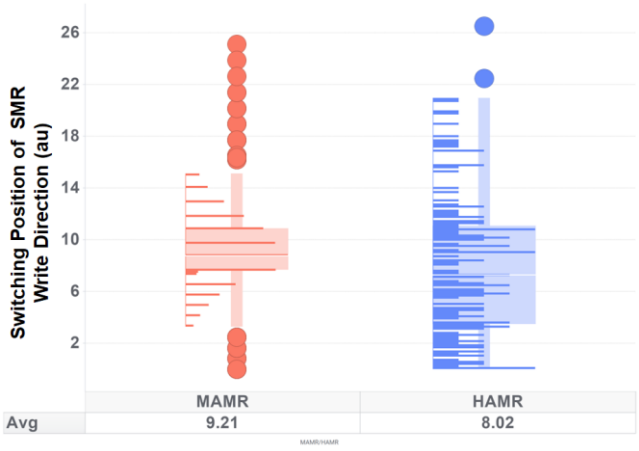

Fig. 3. Comparison of switching position between MAMR and HAMR drives.

Fig.4 shows SMR gain on MAMR and HAMR drives. SMR Gain is calculated by ratio of areal density capability of SMR to that of CMR. Around 20 % of SMR gain is obtained from MAMR drives. On the other hand, HAMR drives are about 2.5 % smaller than MAMR case. This difference is came from HAMR writer properties of less difference at track edge between both side[11]. However, around 18 % of SMR gain are obtained even HAMR drives.

IV. Conclusions

In this study, we compared some SMR properties using MAMR and HAMR drives. Since writing process is completely different both methods, several characteristics show little bit different between MAMR and HAMR. Although the SMR gain of HAMR drives is slightly lower than that of MAMR, it still achieves approximately 18%, indicating the potential for higher areal density with HAMR-based SMR. These results imply that higher areal density can be obtained with HAMR drives applying SMR method.

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