JITTER IN HEAT ASSISTED MAGNETIC RECORDING

J. HOHLFELD[1], P. SUBEDI[1], P.J. CZOSCHKE[1], M. BENAKLI[1]
1) Seagate Technology, Bloomington, USA

I. INTRODUCTION

The linear density capability of magnetic hard disk drives is fundamentally limited by transition jitter. Conventionally, jitter is understood and attributed to two independent sources: i) the random distribution of the location and size of magnetic grains, and ii) the ratio of the switching field distribution and the gradient of the effective write field. Heat assisted magnetic recording (HAMR) is developed to extend the linear density capability of conventional perpendicular recording on the promise that it can reduce both sources of jitter simultaneously. The thermo-magnetic writing process of HAMR not only allows for media comprising much smaller grains but also yields much larger effective write field gradients [1,2].

II. MEDIA SATURATION vs WRITE FIELD

The temperature at which HAMR patterns are written, T_W, is governed by the temperature dependence of the magneto-crystalline anisotropy field, $H_K(T)$, and by the externally applied magnetic write field via: $H_K(T_W) \sim H_{eff}$, where H_{eff} denotes the effective Stoner-Wolfarth write field [3]. This implies that small write fields will not be able to control the magnetization against the impact of strong thermal fluctuations while strong write fields, competing with smaller thermal fluctuations, might yield perfect alignment of all grains. We checked this conjecture by measuring track-averaged amplitudes of 70 nm wide tracks as function of the applied write current (used to control H_{eff}) for media with and without soft magnetic underlayer (SUL). To keep the track-width constant at 70 nm we slightly adjusted the laser power for each write current. The experimental results are compared calculated values of H_{eff} in Figure 1.

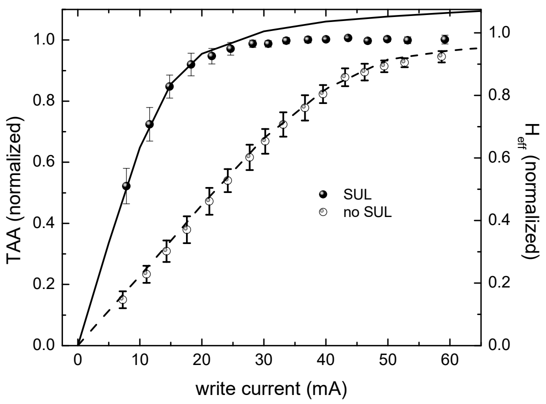

Fig. 1 Comparison of track-averaged amplitudes (TAA, symbols) measured as function of write current for constant track width of 70 nm on media with and without SUL to calculated variations of H_{eff} (solid and dashed line, respectively).

III. JITTER vs MEDIA SATURATION

When measuring transition jitter as function of the applied write field we always find a steep increase of jitter at low write fields that eludes conventional interpretation and mirrors the variations of the media saturation. This finding triggered extensive theoretical investigations on the impact of the media saturation

Julius Hohlfeld
E-mail: Julius.Hohlfeld@seagate.com
tel: +1-952-4027285

on jitter. These studies revealed that jitter indeed depends on the remanent state of the media and should be expressed as sum of squares of three terms:

$$jitter = \sqrt{GS^2 + SFD^2 + \left(c \cdot NSR_{REM}\right)^2} \qquad (1)$$

The first two terms are the conventional contributions due to the grain size- and switching field distributions, whereas the new term depends on the noise-to-signal ratio for the remanence of the media with the prefactor c = (20 ± 1) nm. Figure 2 a) shows the excellent agreement between measured and calculated jitter that can be obtained via Eq. (1), when the write current dependent variations of the remanence shown in Fig. 2 b) are taken into account.

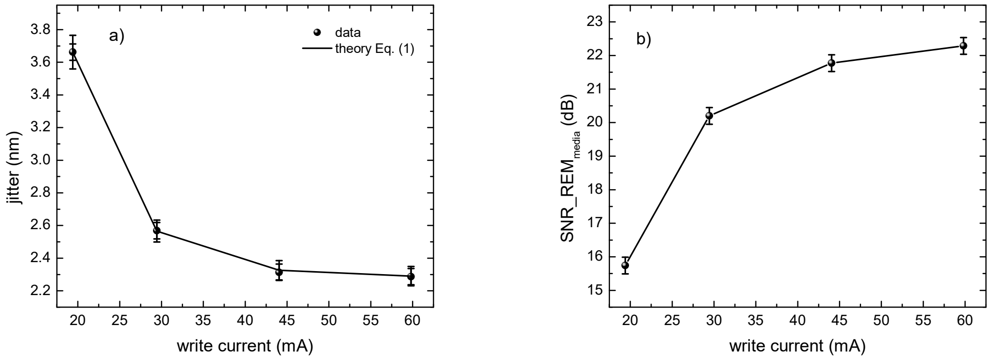

Fig. 2 a) Variations of measured jitter with write current are perfectly reproduced by Eq. (1), when the write current dependent variations of the remanence shown in panel (b) are taken into account.

In our forthcoming paper, we will show that Eq. (1) is generally valid as long as the field rise time is fast enough to ensure that the write field in the vicinity of transitions is equal to the write field governing the remanent state of the media. We will also show that failures of Eq. (1) to reproduce measured jitter can be used to rank field rise-times.

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