# Influence of Magnetic Writer Field on Spin Torque Oscillator Performance

Z. J. Liu, Z. M. Yuan, M. S. Zhang, and Tiejun Zhou

***Abstract*—This paper presents a study of the effect of the magnetic writer field on the performance of the spin torque oscillator (STO) for microwave assisted magnetic recording systems. The effects of the out-of-plane and the in-plane components of the writer field on the field generation layer of the spin torque oscillator are investigated. It is found that the magnetic writer field has significant influence on the STO performance which needs to be taken into consideration in design of the STO writer heads.**

*Index Terms*—**Microwave assisted magnetic recording, Spin transfer oscillator, Finite element methods, Micromagnetics.**

## I. INTRODUCTION

Microwave assisted magnetic recording (MAMR) is one of the promising technique for the next generation hard disk drives of high recording density [1-3]. The performance of the spin torque oscillator (STO) is sensitive to the magnetic writer field. Such sensitivity is in turn affecting the recording quality. This work presents a thorough investigation of the effect of the magnetic writer field on the STO performance. The detailed writer field distribution is computed numerically using finite element methods (FEM) solving Maxwell equation. Both the effects of the out-of-plane and the in-plane components of the writer field on the STO performance are investigated. The field components exerted on the field generation layer (FGL) are taken into consideration in analysis of the status of magnetization and spin dynamics of STO. The influences of the writer head parameters, such as trailing shield gap, are examined. It is found that the magnetic field of the writer head can affect the FGL behavior significantly. In particular, the oscillation state of FGL may be, to an undesirable degree, sensitive to the in-plane component of the writer field (perpendicular to the recording media). It is also demonstrated that field intensity level of such component can be effectively reduced by adjusting the key design parameters of the writer head with wrap-around shield.

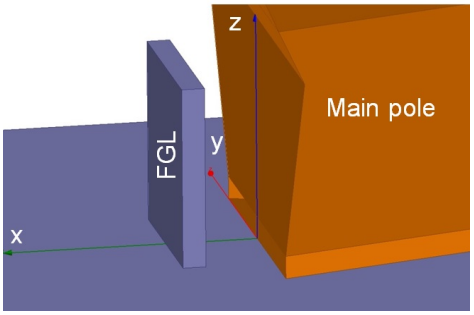
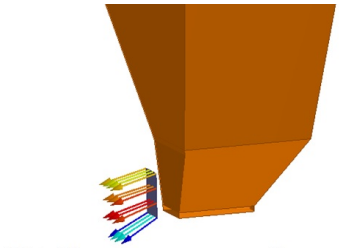



Fig. 1. Schematic view of main pole of writer head and location of FGL of spin torque oscillator.

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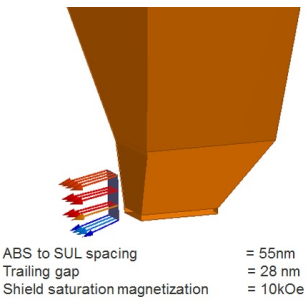


Fig. 2. Distribution of writer field vectors at center plane of FGL with different settings of design parameters.

## II ANALYSIS OF WRITER FIELD

Fig. 1 gives the schematic view of the main pole of a writer head with wrap-around shield and the position of FGL The shield of the writer head is not shown in the figure. At the center plane of FGL the magnetic field vector has both out of plane (in the x-direction, See Fig. 1) and in plane (in the y-direction) components which will may affect the spin dynamics of FGL. The influence of the out of plane components was briefly discussed in Ref [4]. However, the in plane component of the

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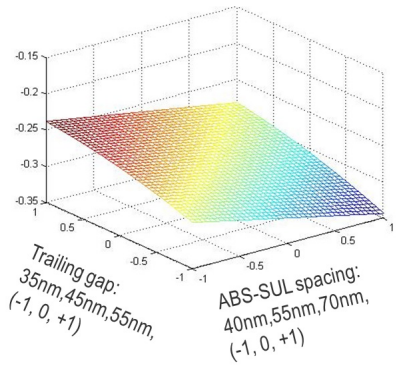
filed intensity is usually very high for a perpendicular writer head, which can also impact on the spin dynamics of FGL, and potentially affect the stability of its magnetization oscillation. Therefore it is of interest to know the dependence of such component on the writer head parameters. Magnetic field analysis shows that the field intensity level of the in plane component due to the magnetic writer field can be controlled to certain degree by adjusting the leading writer parameters, as plotted in Fig. 3, showing the influences of the trailing gap, ABS-to-SUL spacing, and the saturation magnetization of the shield material.

## III PERFORMANCE OF SPIN TORQUE OCILLATOR

The spin dynamics of the FGL has been analyzed using a macrospin model solving the Landau-Llifshitz-Gilbert equation with the effect of spin transfer torque taken into consideration. In the following analysis, the parameters of FGL are as follows, the saturation magnetization, $M_s$ = 1700 emu/cc, the anisotropy constant, $K_u = 8\times10^6$ egr/cc, and the magnetic field in the out of plane direction is 8000 Oe. The spin trajectories of FGL under influence of in plane component of the writer field are shown in Fig. 4. It can be seen that the magnetic writer field acting as the external field to the FGL during writing process, can impact on the FGL behavior is not only due to both of its out of plane and in plane components.

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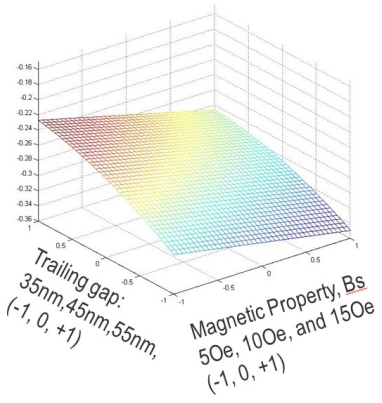


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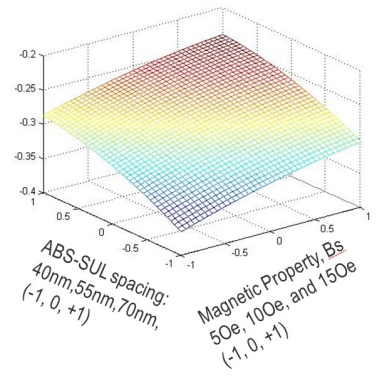


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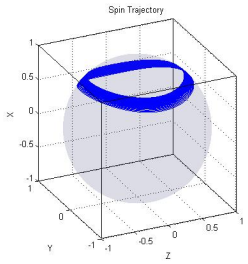
Fig. 3. Dependence of the in-plane component (perpendicular to recording media) of writer field on leading design parameters of writer head.

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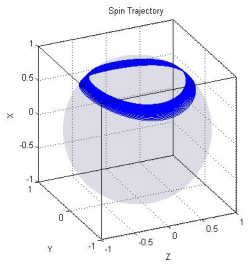


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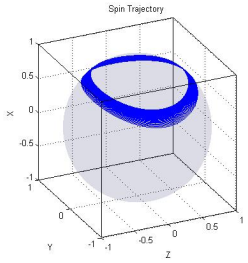


(c)

Fig. 4. Spin trajectory of FGL magnetization under influence of in-plane component of writer field (a) $H_y$ = -2200 Oe, (b) $H_y$ = 0 Oe, (c) $H_y$ = 2200 Oe.

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