Analysis of Spin Torque Nano-Oscillator for Microwave Assisted Magnetic Recording

Y. Y. Guo[1,2], X. G. Li[1,2], and Z. J. Liu[3]

[1]Key Laboratory of Advanced Transducer and Intelligent Control, Ministry of Education of China, China, guoyuanyuan@163.com
[2]College of Physics and Optoelectronics, Taiyuan University of Technology, Taiyuan 030024, China, magheadlxg@126.com
[3]Department of Electrical and Computer Engineering, National University of Singapore, Singapore 117576, eleliuzj@nus.edu.sg

This paper studies the performance of a spin torque nano-oscillators which is integrated with a perpendicular write head for microwave assisted magnetic recording systems. The write head generates both out-of-plane and the in-plane components of the magnetic field in the field generation layer of the spin torque oscillator. The effect of the magnetic write field which is in the out-of-plane direction to the field generation layer was studied previously. Our attention in this work focuses on the effect of the in-plane component. It is found that the magnetic writer field has significant influence on the oscillator performance which needs to be taken into consideration in design of the writer heads for a microwave assisted magnetic recording system.

***Index Terms*—Microwave-assisted magnetic recording, Microwave oscillator, Finite element analysis, Micromagnetics.**

I. Introduction

Amongst various magnetic recording techniques for the next generation hard disk drives (HDD) with extremely high recording density, the microwave assisted magnetic recording (MAMR) [1-4] is a promising technology to meet the ever increasing consumer demand for higher data storage capacity. In a MAMR system, a spin torque nano-oscillator (STNO) is integrated with the write head structure to generate alternating high frequency field that assists the magnetization reversal in the recording media. It is understood that the performance of the spin torque nano oscillator (STNO) is sensitive to the magnetic writer field. Such sensitivity is in turn affecting the recording quality. The effect of the magnetic write field which is in the out-of-plane direction to the field generation layer (FGL) was studied in Ref 5. However, in the area where the STNO resides, the write field also contains a component that is in the in-plane direction to the FGL. The effect of the in-plane write field has not been investigated previously. It is the objective of this paper to present a thorough investigation of the effect of the magnetic writer field on the STNO performance. The level of such in-plane field experienced by the FLG depends of the write head structure incorporated with STNO. 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 STNO performance are investigated. 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 the field intensity level of such component can be effectively reduced by adjusting the key design parameters of the writer head with wrap-around shield.

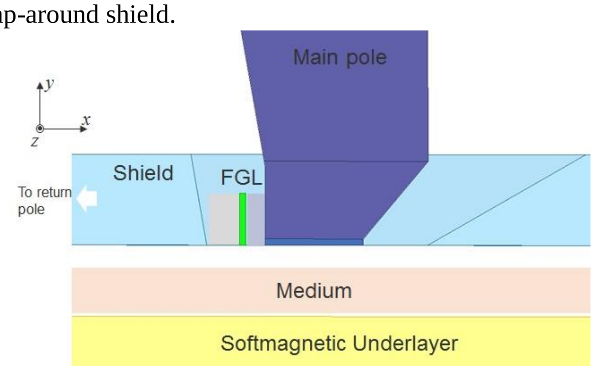

Fig. 1. Magnetization as a function of applied field.

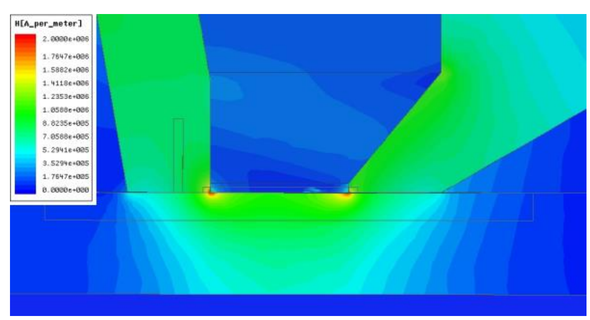

Fig. 2 Distribution of writer field as magnitude of field intensity, Hmag, at z=0 plane.

II. Analysis of Write Head Field

Fig. 1 gives the schematic view of the main pole of a writer head with wrap-around shield and the position of FGL 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 affect the spin dynamics of FGL. The in-plane component of the field 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.

The magnetic write field is analyzed using a software package based on the finite element method (FEM) solving Maxwell equations [6]. The distribution of the write field is illustrated in Fig. 2 showing the magnitude of the field intensity. The distribution of the magnetic field vectors in the center plane of FGL is shown in Fig. 3. The content of the in-plane magnetic field component is clearly observable.

The further analysis of magnetic write field indicates 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 write head parameters including the trailing gap, ABS-to-SUL spacing, and the saturation magnetization of the shield material.

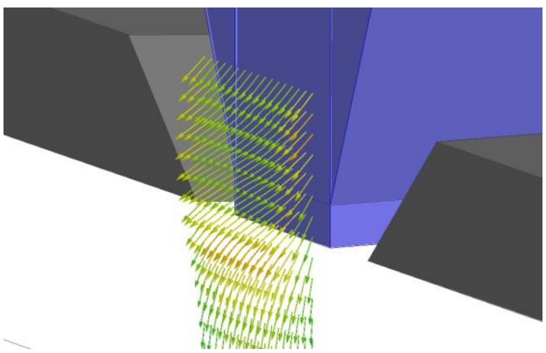

Fig. 3 Distribution of writer field vectors at center plane of FGL with different settings of design parameters.

III. Analysis of Spin Torque Oscillator Performance

The spin dynamics of the FGL has been analyzed using a macrospin model solving the Landau-Lifshitz-Gilbert equation with the effect of spin transfer torque taken into consideration [7]. In the following analysis, the parameters of FGL are as follows, the saturation magnetization, Ms = 1700 emu/cc, the anisotropy constant, Ku = 7.5×106 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. The magnetic writer field which is a function of the excitation current waveform acts as the external field to the FGL during writing process, Its impact on the FGL behavior is due to both of its out of plane and in plane components. The influence of the current wave from injected to the write circuit will be presented in the full paper.

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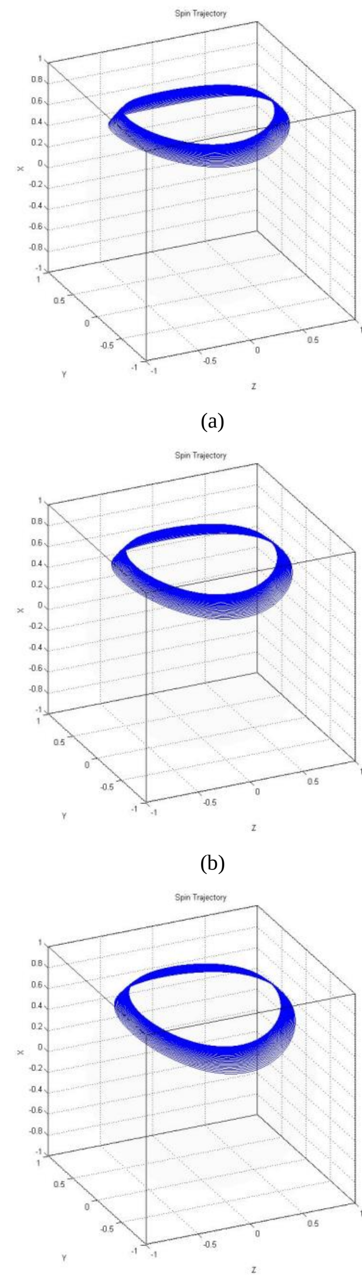

(a) (b) (c)

Fig. 4. Spin trajectory of FGL magnetization under influence of in-plane component of writer field (a) H_y = -2000 Oe, (b) H_y = 0 Oe, (c) H_y = 2000 Oe.