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Effect of shields in perpendicular recording

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Abstract

Micromagnetic simulations have been used to investigate magnetization dynamics in a perpendicular recording head with a trailing shield. The numerical experiment was carried out on a set of head models with shields. Trailing shields used in modelling had a thickness of 20 nm and spacing of 50, 100 and 150 nm from the trailing edge of the tip. Results of our investigations show that shields not only increase the gradient of the recording field but also help to generate more surface charges on the tip and on the SUL below it. For specific configurations and head to shield spacing (>50 nm) this leads to higher field magnitudes, leading to the 4–6% increase in the perpendicular field at 10 nm below ABS.

Keywords: Perpendicular recording; Recording head; Trailing shield

1. Introduction

Perpendicular magnetic recording has proved itself as an advantageous method of storing information today [1–3]. This technology has come to take the lead from the conventional longitudinal recording due to its high-density capabilities and ability to write on media with higher switching fields. Up to recent years the areal density of recording has been improved by reducing the size of grains in the media. But the superparamagnetic limit pushes media designs to use harder magnetic materials for grains to ensure that thermal fluctuations do not destroy written bits. The limitations of the magnetic fields produced by modern recording heads boosted developments of new recording media concepts such as exchange coupled media (ECC) and gradient media [4,5]. In this work we try to develop an optimal head design for the latter. More detailed information about the gradient media can be found elsewhere [5]. This new technology requires a new head design for the following reason: in contrast to the conventional perpendicular recording media, where the minimum switching field is for angles close to 45° (S-W approximation), the gradient media requires a high perpendicular field due to the nature of the domain wall assisted switching [5–7]. In addition to the high magnitude of the field, a steep gradient is also required to reduce erasure of written bits. These requirements bring new challenges to the recording head designs. It was shown in previous studies that the field gradient can be significantly improved by placing a magnetic shield close to the pole tip [8]. Since the magnetic flux is allowed to leak into the shield, the perpendicular component of the magnetic field below ABS is reduced. In this paper we present results of further investigations of how a trailing shield can affect the perpendicular field in a datalayer using full LLG modelling.

2. Method

Micromagnetic simulations have been performed using the time integration of the LLG equation combined with a hybrid FEM/BEM method [9]. LLG simulations are helpful in studying a local magnetization response to the local effective field, since there is a constant feedback between the magnetization and the effective field, generated by its state [9]. The open boundary and magnetic potential problems, which arise from the effective field calculations are effectively treated by means of FEM/BEM with the help of hierarchical matrices [9,10]. For the simulation model we created an entire write head including a yoke, pole tip, soft underlayer (SUL), return pole and trailing

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shield. The trailing shield had a rectangular shape and was connected to the return pole. The ABS to SUL spacing was 30 nm with SUL itself having a thickness of 150 nm. Pole tips with dimensions 90×40 nm in x–y and from 10 to 80 nm in z, were modelled for FeCo with $\mu_0 M_s = 2.4$ T, $A = 2.015\text{e}{-11}$ J/m and $K = 800$ J/m^3. All other parts of the head model, including the shield, had $\mu_0 M_s = 2.0$ T, $A = 1.3\text{e}{-11}$ J/m and $K = 800$ J/m^3. The model was meshed using tetrahedral finite elements. The mesh size was 5 nm in the pole tip. Also the 5 nm size was used in the regions of the shield and SUL that are close to the tip. The magnetization was driven by a write current with a maximum value of 110 mA, and a rise time of 0.1 ns through a pane cake shaped coil. All simulations were started from the remanent state and continued for 3 ns.

3. Results and discussion

The perpendicular field analysis was carried out using method described in Ref. [11]. Results of simulations were processed to obtain down-track field profiles for 10, 40 and 80 nm throat heights. The trailing shield spacing varies from 50 to 150 nm for 40 and 80 nm throats. For 10 nm throat there are also 30 and 200 nm spacings. Fig. 1 shows the down-track profile of the perpendicular field at the trailing edge for 10 nm throat height and three shield positions. We show here only 30, 50 and 100 nm spacings compared with unshielded head field profile. Figs. 2 and 3 show analogous plots for 40 and 80 nm throats. It is clear

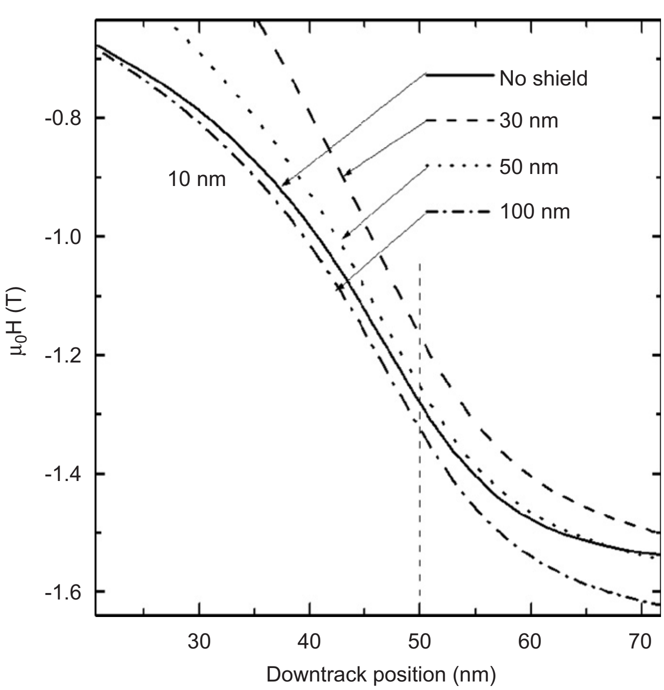

Fig. 1. Magnified down-track field profile for the head with a 10 nm throat height near the trailing edge versus x-position after 2.5 ns. Position of the trailing edge is at 50 nm (shown as a vertical line). Data is presented for 30, 50 and 100 nm shield spacings.

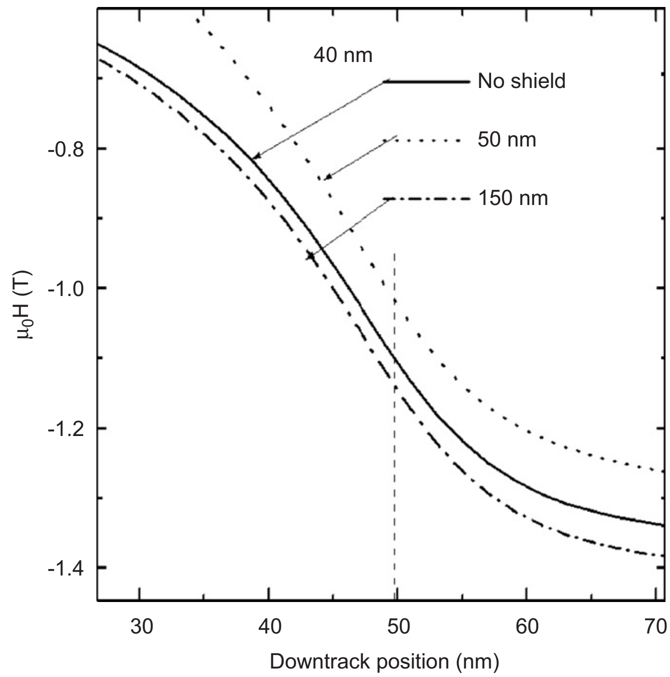

Fig. 2. Same as in Fig. 1 but for 40 nm throat height.

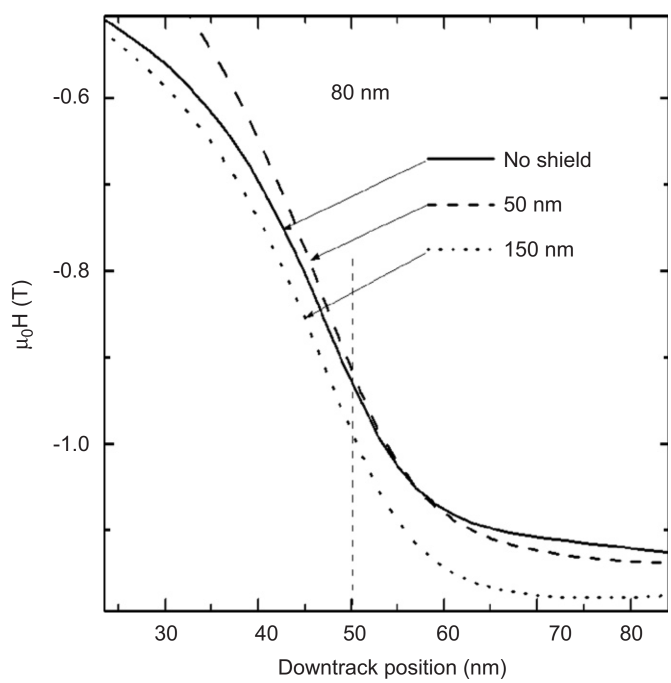

Fig. 3. Same as in Fig. 1 but for 80 nm throat height.

from these graphs that placing the shield at 50 nm and closer leads to high gradient values but the perpendicular field is reduced due to large amount of flux leaked into the shield. Moving the shield further helps to increase the perpendicular field and slightly reduce the gradient. This increase is between 3% and 6% as compared to unshielded head. These results suggest that there is an optimum spacing where high B values at the trailing edge can be