

GLOBAL OPTIMIZATION OF PERPENDICULAR WRITERS

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I. INTRODUCTION

Pole tip shape and write gap strongly influence the characteristics of the write field. We combine finite element micromagnetics and a response surface method for global optimization, in order to design writers for magnetic recording at densities beyond 6 Tbit/in². In particular we focus at writer designs for exchange spring or composite media, where the optimal write field angle is in about 20 degrees. Using a head that is perfectly adjusted to the switching properties of the media may help to push recording towards higher densities without the need of energy assist technology. Optimization techniques for writer design that are based on finite element magnetic field solvers have been used by Okamoto and co-workers [1]. Kanai and co-workers [2] used micromagnetic simulations to compare different single-pole structures for perpendicular recording.

II. GLOBAL OPTIMIZATION

Within the framework of our global optimization method at each iteration step a response surface model of the objective function, the product of write field with the field gradient, is constructed in the current search region. The surface model is used to find the next best trial step. For the current optimal point the true objective function is evaluated and the result of the computation is used to refine the response surface. This optimization techniques works for non-differential as well as for stochastic objective functions. By creating a hierarchical decomposition of the parameter space, the global minimum can be found. This method [3] was used for the optimization of perpendicular writers, whereby the optimization algorithm was combined with a finite element / boundary element micromagnetics solver [4].

III. RESULTS

We applied global optimization to optimize the bevel angles in single pole writers for exchange spring, bit patterned media and to optimize the design shields. The optimal angle at the trailing edge was found to be approximately 60 degrees, whereas the optimal angle at the leading edge was found to be 30 degrees. These optimal values are nearly independent of the pole tip width and head to soft underlayer (SUL) distance. Optimized pole tips show curved, pyramidal shapes with a bevel angles at the trailing edge and cross track edge of about 65 degrees. Figure 1 shows the optimal three 3D shape of the pole tip of an unshielded head. The shape was optimized for bit patterned media with a periodicity of 8 nm. The head to SUL distance was 20 nm. Figure 2 gives the perpendicular write field component computed at different distances from the air bearing surface (ABS) using finite element / boundary element micromagnetics. Similar tapered head structures are discussed in [5] and the references therein.

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The use of a micromagnetic solver to evaluate the magnetic field is essential for the design of shielded heads. The presence of a shield not only bends the write field but may also change the magnetization configuration in the pole tip. In particular, the shield may suppress the formation of a twisted flower state in the pole tip. As a consequence an optimal shield design can be found that improves both field gradient and perpendicular write field.

IV. HEAD/MEDIA OPTIMIZATION

A further improvement can be obtained if high thermal stability of the media and low adjacent track erase will be added to the objective function. Media parameters such as local anisotropy and its gradient will be part of the parameter space. Thus a true joint optimization of write head and media is possible. Using this technique to optimize the writer geometry for recording on bit patterned media, the write field is maximized in the target islands and minimized on its trailing edge and cross track neighbors.

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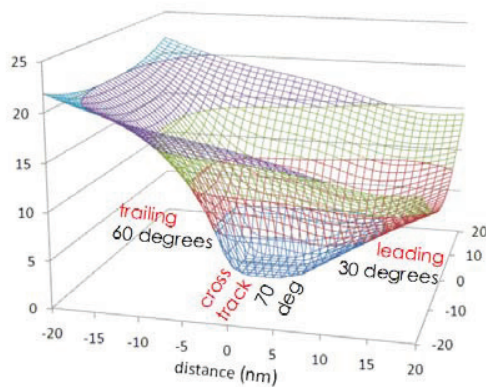


Fig. 1 Three dimensional contour of the pole tip. The shape was optimized for bit patterned recording with a down-track and cross-track periodicity of 8 nm.

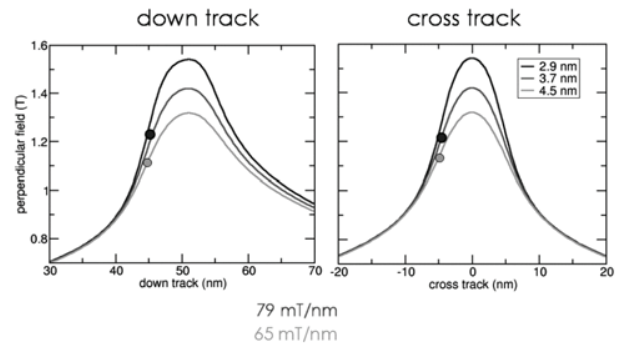


Fig. 2 Down-track and cross-track profile of the perpendicular write field. The write field component is shown at different distances (2.9 nm, 3.7 nm, and 4.5 nm) below the ABS.