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Information Storage

Effects of Island Volume and Hotspot Position Fluctuation for Heated-Dot Magnetic Recording

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Abstract—Heated-dot magnetic recording (HDMR), which employs the laser to heat a bit-patterned medium before recording data, is a promising technology to achieve an ultra-high recording density. Generally, many parameters can cause an error during the writing process in an HDMR system; however, this letter investigates only the effect of bit island volume, bit island position fluctuation, and hotspot position fluctuation. Specifically, three bit island volumes are considered, i.e., 1100, 860, and 620 nm^3. In addition, we also study the 3-by-3 data patterns that easily cause an error when the hotspot and write head positions have fluctuated. To achieve an error-free writing process, the heating temperature is studied using the Brillouin function for thermal calculations. Implementation of treating the hotspot and evaluating the thermal effect is explicitly described. Simulation results indicate that the smaller the position variation, the lower the error percentage. Moreover, we found that the error percentage is decreased as the heating temperature is increased. Finally, it is apparent that the smaller the island volume, the lower the error percentage.

Index Terms—Information storage, bit-patterned media, heat-assisted magnetic recording, write errors.

I. INTRODUCTION

To achieve an extremely high areal density (AD) in magnetic recording systems, we need to overcome two hindrance parameters encountered in a conventional magnetic recording system, namely a superparamagnetic limit and magnetic transition noise. A bit-patterned medium (BPM) is one promising technology for solving these two problems; however, the thermal stability of BPM could still be a concern. This results from the use of high magnetocrystalline anisotropy (K_u) material such as $L1_0$-FePt, which is generally adopted as a magnetic medium. Practically, a high K_u medium also requires a high magnetic field strength to record the data onto a medium. Nonetheless, a current write field value cannot exceed the limit of about 24–25 kOe [Fang 2014]. Thus, a medium coercivity must be reduced before recording data. This can be done by utilizing a heat-assisted magnetic recording (HAMR) technology, where the laser is employed to heat a medium at near the Curie temperature before writing the data. In practice, the thermal spot size is a challenge of the HAMR technology [Kyder 2008] because it normally determines the AD (i.e., the smaller the spot size, the higher the AD).

Recently, a new technology known as heated-dot magnetic recording (HDMR) [Ghoreyshi 2014, Tipcharoen 2016] is employed to enable the AD up to 10 Terabit per square inch (Tbpsi). The HDMR technology combines the techniques used in HAMR with BPM and, possibly, two-dimensional magnetic recording (TDMR) [Lin 2013]. Practically, the heat is applied on the island while the data bit is being written. In general, the inappropriate thermal distribution and write head field gradient that cover the neighboring recorded bits in both down- and cross-track directions can cause a written-in error during the writing process. Additionally, this written-in error can result from bit island position jitter, main pole position fluctuation, heat spot position, and so on [Lin 2013, Asbahi 2014, Vogler 2016]. Therefore, the durability of recorded-bit patterns against these effects should be understood before recording the data onto a medium.

In this letter, we investigate the effects of heat spot and bit island position fluctuations in the HDMR system. We also analyze the effect of island volumes at various heating temperatures. The thermal effect on BPM is evaluated via the Brillouin function [Thiele 2002, Akagi 2012], which is the relationship between a magnetic material and temperature. Then, the micromagnetic simulation is utilized based on the Landau–Lifshitz–Gilbert (LLG) equation [Donahue 1999, Zhang 2012].

The rest of this letter is organized as follows. Section II describes a micromagnetic modeling. Simulation results and discussion are given in Section III. Finally, Section IV concludes.

II. MICROMAGNETIC MODELING

We consider micromagnetic modeling based on the LLG equation. Three cylinder bit island volumes are considered, i.e., 1100, 860, and 620 nm^3, which will be referred to as large, moderate, and small volume, respectively, and the thickness of all cases is set to 10 nm.

The island pitch of both down- and cross-track directions is 15 nm, corresponding to the AD of 2.86 Tbpsi. The high anisotropy material $L1_0$-FePt is used as a magnetic medium with K_u of 4.6 MJ/m^3, the saturation magnetization, M_s, of 1125 kA/m [Thiele 2002], the exchange coupling intra-island of 12 pJ/m [Wang 2011, Zhang 2012], and the Curie temperature, T_c, of 770 K [Thiele 2002].

The thermal evaluation via micromagnetic simulation in this work can be summarized as follows.

1) The bit-patterned layout specifications are created according to the three island volumes, where each island has different easy axis declined between 0° and 20° [Tipcharoen 2016].

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