COMPOSITE MEDIA FOR HIGH DENSITY HEAT ASSISTED MAGNETIC RECORDING

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I. INTRODUCTION

Exchange coupled composite media (ECC media) has been widely adopted by the hard disk drive industry for use in perpendicular magnetic recording. Important benefits include mitigation of the magnetic recording trilemma (balance of thermal fluctuations versus grain size and write field) and reduction of the switching field distribution. The resulting SNR improvements enable higher areal density. However, this media too is ultimately limited by the trilemma, and densities beyond 1 Tbit/in^2 (conventional system) or 1.5 Tbits/in^2 (systems incorporating shingled recording and/or TDMR) seem difficult to achieve. Heat assisted magnetic recording (HAMR) is the most promising candidate for next-generation magnetic recording technology: it breaks the trilemma by heat. L10 FePt media is usually considered for HAMR recording media that requires high anisotropy and small grain size. However, the recording temperature of HAMR is elevated to temperatures near the Curie temperature of FePt. Both magnetization and anisotropy of FePt are small at these temperatures. Therefore, thermal fluctuation and Curie temperature variance become two main noise sources owing to the resultant small Zeeman energy and poor thermal stability.

A composite media design with a superparamagnetic write layer and L10 FePt storage layer is proposed to mitigate the noise. The simulation results show that this structure can greatly decrease the transition noise and be insensitive to the Curie temperature variance in the L10 FePt storage layer. The areal density can reach as high as 4.7 Tb/in^2 for a Gaussian heat spot with a full-width-at-half-maximum of 30 nm, a 12 nm reader width, and an optimized bit length of 6 nm [1]. Further investigation also finds that the interlayer exchange coupling plays an important role in tuning the average write temperature and effects from thermal fluctuation.

II. MEDIA DESIGN AND MODEL

Micromagnetic simulation based on the Landau-Lifshitz-Gilbert (LLG) equation is implemented. A renormalization approach [2] with 1.5 nm renormalized cubic cells and parallel computing under NVIDIA GPU architecture are used to improve the simulation speed. The switching probability distribution (SPD) [1] is calculated to predict the optimal magnetic properties of the composite media. The average write temperature is defined as the one at which the switching probability is 50% during the dynamic cooling process. The full-width-at-half-maximum FWHM of the SPD curves provide an estimate of total noise. Based on these two parameter, the optimal structure is: $M_{s,wl}$=550 emu/cm^3, $K_{u,wl} = 7 \times 10^6\ erg/cm^3$ and $T_{c,wl}$=900K. The thickness of two layers is 4.5 nm (write layer) and 9.0 nm (storage layer). The temperature profiles of the write layer are scaled based on the magnetic profiles of FePt. [1] $M_{s,sl} = 922\ emu/cm^3$ and $K_{u,sl} = 4.11 \times 10^7\ erg/cm^3$ at 350 K. $T_{c,sl} = 700K$. Here, “sl” stands for the storage layer and “wl” represents the write layer. The head velocity is chosen to be 20 m/s. The applied magnetic field is 8000 Oe with uniform distribution inside the heat spot.

III. TRANSITION JITTER AND USER DENSITY

Transition jitter is defined as the standard deviation of zero-crossings of play-back signal along the down-track direction. It is proportional to transition noise. The recording simulation results under 5.5 nm grain pitch and various Tc variance of storage layer are shown in Fig. 1(a). Single FePt recording media suffers from Tc variance. Larger Tc variance causes more noise in single FePt media. However, the composite media is insensitive to Tc variance and greatly reduces the transition jitter. The magnetic recording system is optimized in terms of heat spot size, bit length and reader width. The track pitch is also optimized to enhance the user density without making any changes to the reader configuration. Fig. 1(b)

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shows the user density and effective bit ratio C/BL. Here, C is Shannon capacity calculated based on bit error rate (BER) [1]. BL is bit length. The BER is found statistically by repeatedly recording a pseudo random bit sequence on the composite media. The highest user density that can be achieved is 4.7 Tb/in^2.

IV. INTERLAYER EFFECTS

The strength of exchange coupling between both layers is tuned by $ILC = J_{ex}/J_o$. Here, $J_o \propto \sqrt{A_{ex,wl}A_{ex,sl}}$. Careful investigation shows that stronger interlayer exchange coupling increases the average write temperature and decreases the FWHM of the corresponding SPD defined in section II. FWHM only include the effects from thermal fluctuation with no Tc variance assumed in either layer. An analytic theory based on energy barrier calculation is proposed. These interesting trends are due to the linearity of energy barrier versus temperature at the high temperature region close to the Curie temperature [3].

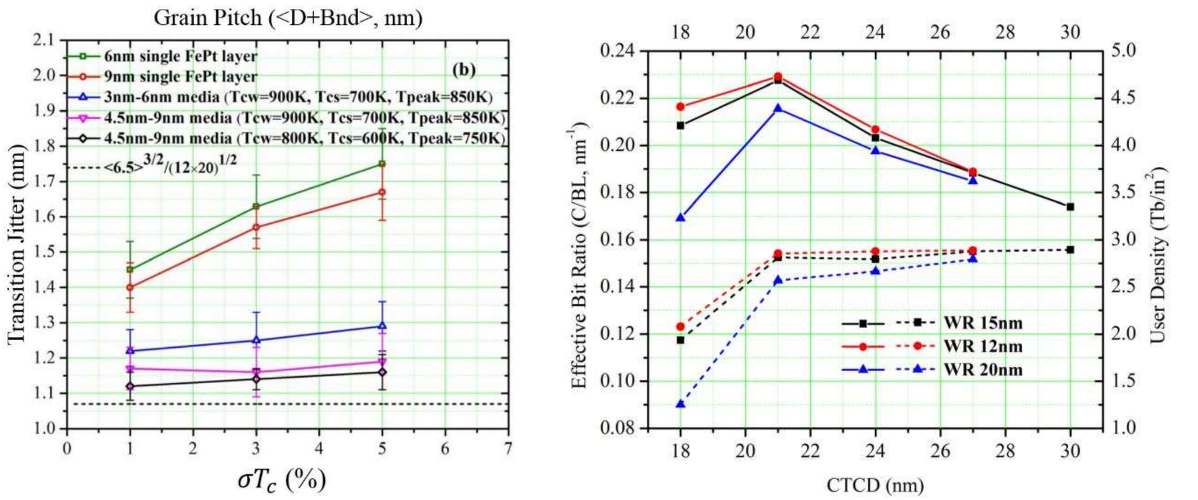

Fig. 1 (a) shows the transition jitter versus $\sigma T_{c,sl}$. (b) shows the C/BL (dashed) and user density (solid) versus track pitch.

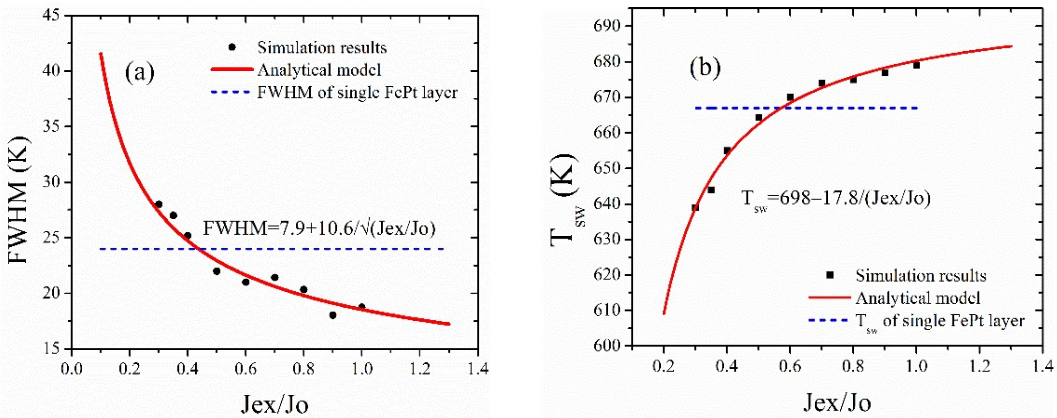

Fig. 2 (a) shows the FWHM versus ILC=Jex/Jo. (b) shows the average write temperature versue ILC.

REFERENCES

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