Microwave assisted magnetic recording on ECC and AFC media

S. J. Greaves [1], Y. Kanai [2] and H. Muraoka [1]

[1] Research Institute of Electrical Communication, Tohoku University, Sendai, Japan
[2] IEE, Niigata Institute of Technology, Kashiwazaki, Japan

Introduction

Microwave assisted magnetic recording (MAMR) is a possible technology for use in future hard disk drives [1]. The simultaneous application of a DC field from a write head and a high frequency (HF) field from a spin torque oscillator (STO) can locally reduce the switching field of media in the vicinity of the STO, leading to a higher effective head field gradient and improved SNR. In this work we present results of simulations of two types of media: exchange coupled composite (ECC) and antiferromagnetically coupled (AFC) and consider their behaviour in a MAMR system.

ECC media

The use of ECC media in a MAMR system offers advantages such as a reduced resonance frequency and enhanced MAMR effect. Fig. 1 shows the switching fields of the hard layers of 4 nm hard + x nm soft ECC grains subjected to a 500 Oe HF vector field rotating in the plane perpendicular to the easy axis. Without the HF field the switching field was about -16.5 kOe for all grains. With the HF field the switching field decreased rapidly once the soft layer thickness exceeded 4 nm. The switching field changed sign for soft layer thicknesses between 6 nm and 8 nm, i.e. the hard layer magnetisation switched before the applied field reached zero, as shown by the inset hysteresis loop for a grain with a 7 nm soft layer.

The same effect can be realised in a recording medium. A static planar write head with a STO was used to write single bit footprints on AC-erased ECC media. The average change of magnetisation is shown in fig. 2 as a function of down-track position, together with the vertical component of the head field at each point. It can be seen that the magnetisation switched in the opposite direction to the head field, with peaks under the edges of the STO (position indicated by the darker shaded region).

When the head field was zero no magnetisation switching was observed, but [2] describes conditions in which the HF field alone can switch the magnetisation direction. Tuning the STO and medium properties may enable this effect to be realised.

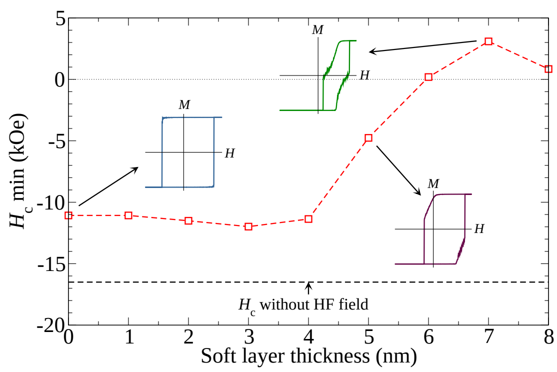

Fig. 1: Minimum switching field of hard layer on descending part of hysteresis loop vs. soft layer thickness. 500 Oe in-plane HF field.

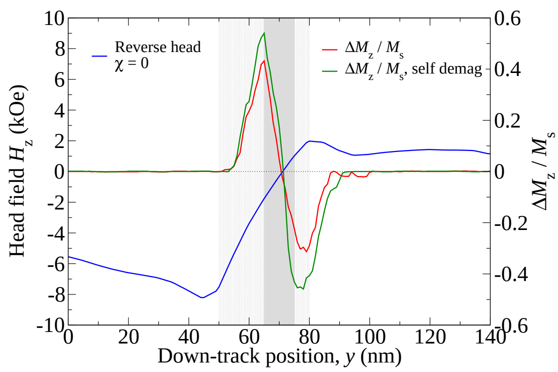

Fig. 2: Change of medium magnetisation, ΔM, as a function of down-track position for footprints written by a planar head and HF field from a STO.

AFC media

Another advantage of MAMR is the possibility to realise multiple layer recording [3]. Selective recording of each layer in a medium with two or more recording layers is possible if the layers have different resonance frequencies. However, the spacing between the recording layers cannot be large as the HF field and head field rapidly decrease in strength with distance from the ABS. As a result there can be strong magnetostatic interactions between the recording layers. To mitigate these interactions the use of AFC media has been proposed [4].

Fig. 3 shows hysteresis loops of single layer (SL) and AFC media. The thickness of both media was 11 nm and the AFC medium had the structure 4 nm hard / 1 nm Ru / 6 nm soft. The saturation magnetisation of the hard layer was 600 emu/cm^3 and that of the soft layer was 400 emu/cm^3. In zero field antiferromagnetic coupling between the hard and soft layers of -1 erg/cm^2 led to an anti-parallel magnetisation state and almost zero remanence. The hard layer of the AFC medium had the same switching field, 20 kOe, as the SL medium. In contrast to ECC media, switching of the soft layer in AFC media did not initiate reversal of the hard layer due to the large difference in switching fields between the two layers.

Tracks were written on SL and AFC media at various linear densities. At low densities the SNR was similar or slightly higher for the SL media. However, as the linear density increased the SNR of the SL media decreased whilst the AFC media SNR was almost unchanged. Fig. 4 shows averaged readback signals of ten tracks written on SL and AFC media at 1693 kfci (15 nm bit length). Although the signal from the AFC media was lower due to the anti-parallel magnetisation, the noise was much reduced, as evidenced by the smaller fluctuations in peak height and much lower transition jitter. Other properties of AFC media will be discussed in the talk.

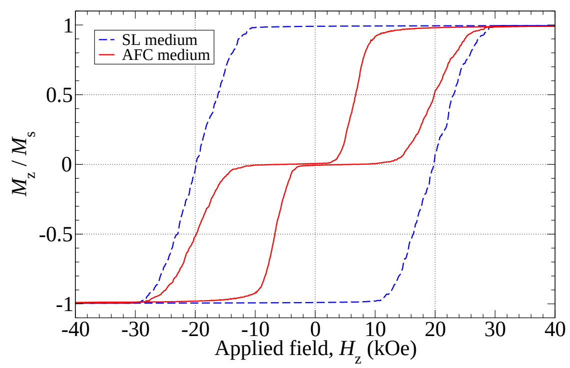

Fig. 3: Hysteresis loops of single layer (SL) and AFC media. K_u hard / SL = 8×10^6 erg/cm^3.

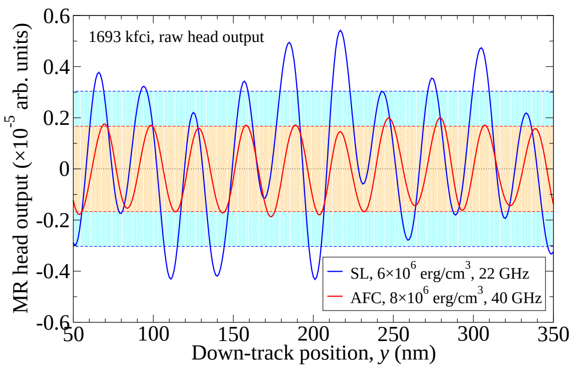

Fig. 4: MR head output signal for 1693 kfci tracks written on SL and AFC media.

References

[1] J. G. Zhu, X. Zhu, and Y. Tang *IEEE Trans. Magn.*, vol. 44, pp. 125–131, Jan. 2008.

[2] T. Taniguchi *Appl. Phys. Expr.*, vol. 8, pp. 083004–1–4, 2015.

[3] S. J. Greaves, Y. Kanai, and H. Muraoka *IEEE Trans. Magn.*, vol. 53, pp. 3000510–1–10, Feb. 2017.

[4] H. Suto, T. Nagasawa, K. Kudo, K. Mizushima, and R. Sato *Nanotechnology*, vol. 25, pp. 245501–1–8, 2014.