Microwave assisted magnetic recording on media with multiple, discrete recording layers

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), in which a spin torque oscillator (STO) is used to locally reduce the switching field of a recording medium, allowing information to be recorded on high anisotropy media, is actively being developed for use in future hard disk drives.

If a recording medium has two discrete recording layers it is possible to use MAMR to selectively record on one layer or the other by tuning the frequency of the STO to the resonance frequency of the target recording layer. Given that the spacing between the two recording layers must be small, e.g. 1 - 3 nm, magnetostatic interactions between the layers become a problem. In this work we examine the requirements for multiple layer recording and possible options to reduce the effect of magnetostatic interactions between layers, and between grains within the same layer.

AFC media

Antiferromagnetically coupled (AFC) media were originally developed for longitudinal recording [1], however, it is also possible to make perpendicular AFC media [2]. In such structures, consisting of two magnetic layers separated by a material such as Ru or Ir, an anti-parallel alignment of the magnetisation is favoured, reducing the stray magnetic field emanating from the structure.

In addition to reducing magnetostatic interactions between AFC structures, interactions between grains in the same structure are also reduced. This results in much higher signal to noise ratios (SNR) for tracks written at high linear densities as a result of lower transition jitter [3]. An example of this is shown in fig. 1, which shows the positions of 600 transitions written on AFC and single layer (SL) media. Fits with error functions show the reduction in transition jitter when using AFC media.

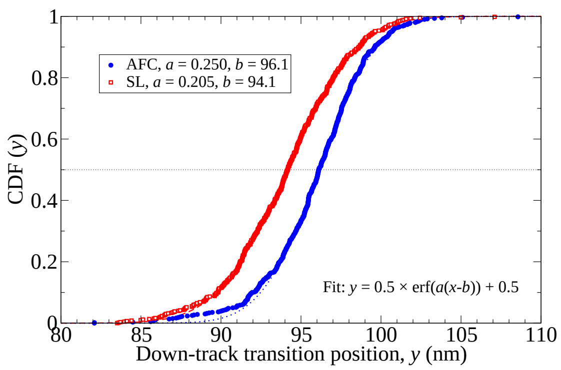

Fig. 1: Positions of 600 transitions written on AFC and single layer (SL) media. 30 nm bit length.

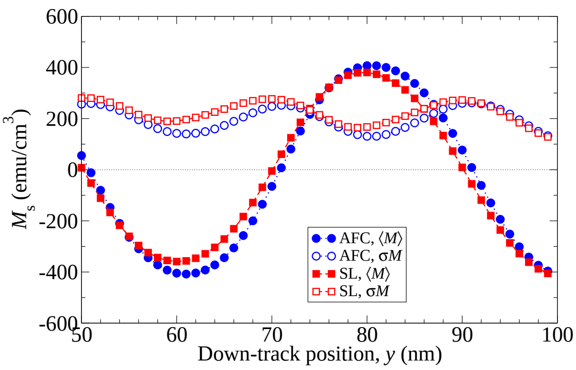

Fig. 2: Average magnetisation and standard deviation of the magnetisation of two 20 nm-long bits written on AFC and SL media. Magnetisation of AFC hard layer is shown.

A second reason for the higher SNR of AFC media is a reduction in magnetisation fluctuations within written bits. Fig. 2 shows the average magnetisation of bits written on AFC and SL media. The magnetisation of the hard layer of the AFC media is shown. The bits written on AFC media had slightly higher average magnetisation, but the standard deviation of the magnetisation was lower, resulting in lower noise during readback.

Media with two discrete recording layers

To select the properties of each layer in a medium containing two discrete recording layers an analysis similar to that shown in fig. 3 is carried out. For a given head field and high frequency (HF) field generated by a STO the maximum switchable H_k of grains in recording layers 1 and 2 (RL1 and RL2) is calculated. Subsequently, H_{k1} is chosen such that a grain in RL1 can be switched by a HF field of frequency f_1, but cannot be switched by f_2. H_{k2} is chosen in a similar manner.

Having determined the H_k and HF field frequencies, tracks can be written on each layer. Magnetostatic interactions between layers favour a parallel alignment of the magnetisation in RL1 and RL2 which can degrade the recording performance. To counteract this a small amount of antiferromagnetic exchange coupling, J_{IL}, can be introduced between RL1 and RL2. Fig. 4 shows the SNR of tracks written in RL1 and RL2 with and without antiferromagnetic exchange [4]. The SNR was increased when antiferromagnetic exchange was used. An alternative approach is to use AFC structures in RL1 and RL2. However, this will not completely eliminate magnetostatic interactions between the layers.

Fig. 4 also shows a strong dependence of the SNR on the write head velocity. The main cause of the SNR reduction at higher head velocities was a decrease in the magnetisation switching probability. This suggests that there is some critical part of the HF field that initiates magnetisation reversal.

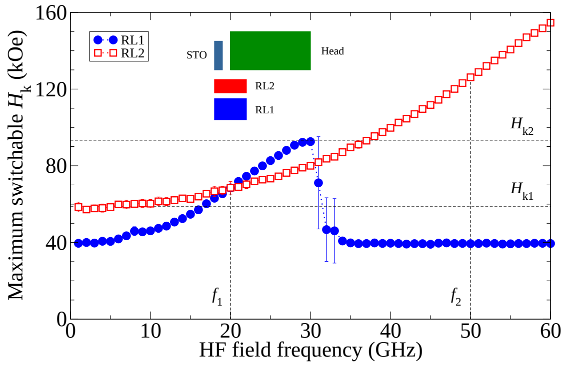

Fig. 3: Maximum switchable H_k of grains in RL1 and RL2 as a function of HF field frequency. Structure is: 7 nm RL1 / 2 nm IL / 5 nm RL 2 / 3.5 nm Air / Write head

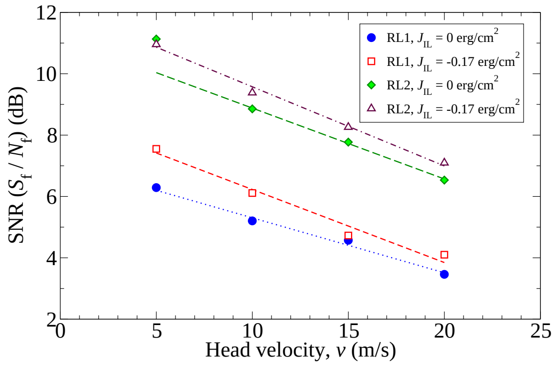

Fig. 4: SNR vs. write head velocity for 847 kfci tracks written on RL1 and RL2 with and without antiferromagnetic coupling between RL1 and RL2.

References

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