CONCEPTS OF MAGNETIC 3D AND MULTILAYER RECORDING MEDIA

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Hard disk media that support ultra high densities require small grains in order to obtain high signal to noise ratios. The use of high coercive materials such as alloys in the L10 phase allow for thermally stable grains at grain diameters in the order of 4nm . However, state of the art write heads produces too small fields to reverse these extremely hard magnetic grains. Recently composite media and exchange spring were proposed in order to decrease the write field requirements [1,2]. In exchange spring media an ultra hard magnetic storage layer is strongly exchange coupled to a softer magnetic nucleation host layer. The nucleation host decreases the switching field of the storage layer up to a factor of five without lowering the thermal stability of the entire structure. If the nucleation host is composed of multiple magnetic layers where the anisotropy increases from layer to layer it was shown that the resulting structure has a high thermal stability whereas at the same time the coercive field decreases with one over the total layer thickness [3]. Exchange spring media can be switched extremely fast due to precessional switching. Field pulses with a total length of 20 ps are sufficient to reproducibly reverse a grain.

In the second part of the talk a concept of 3-D recording, where multiple layers are addressed independently is investigated. The basic idea is to design a media in a way that the anisotropy in each layer is sufficient large so that the static head field can not reverse any of the layers. Since the head field decays with increasing head to media distance the previously mentioned requirement leads to smaller anisotropy values of the bottom recording layer. Writing is assisted by applying a linearly polarized microwave fields in the film plane [4]. Since the anisotropies in the bottom layer and the top layer are different, also different microwave frequencies are required in the top and bottom layer to meet the resonance condition. In resonance the largest reduction of the write field is observed.

Simulations on patterned elements with dimensions of 20 nm x 20 nm are investigated. The top layer thickness is 2.4 nm and the bottom layer thickness is 3.5 nm. The head to media distance of the top layer and bottom layer is 2 and 8 nm respectively. The distance between the two layers is 3.6 nm. A precomputed head field was used for the recording application. In the centre of the top layer (at a distance 3.2 nm away from the head) the head field is 1.3 T. In the centre of the bottom layer (10nm) the head field strength is 0.96 T. The magnetic polarization in both layers is $J_s = 0.2$ T and the exchange constant is $A = 10^{-11}$ J/m. The anisotropy in the top layer and bottom layer is 0.21 MJ/m³ and 0.142 MJ/m³, respectively.

Phase diagrams are calculated to design the dual layer patterned media. Fig. 1 (a) and Fig. 2 (a) show the regimes of switching (red) and not-switching (blue) for a field pulse with a field rise time of 0.1 ns. The damping constant is 0.05. Since the bottom layer is further away from the AC field source we have used a smaller magnitude of the AC field of 0.08 T at the bottom layer, whereas it is 0.12 T in the top layer. The phase diagrams indicate that the resonance frequency of the top layer and bottom layer is about 28 GHz and 16 GHz, respectively.

In a second step recording simulations are performed in the dual layer media. Initially, the magnetization in all elements is pointing up, indicated by the red color. A bit pattern with a sequence of 1010 was tried to record independently on the top layer and bottom layer on the centre track. As predicted by the phase diagrams, we could independently reverse the elements in the bottom layer and top layer.

References:

[1] R. H. Victora and X. Shen, “Composite media for perpendicular magnetic recording”, IEEE Trans. Magn., 41 (2005) 2828-2833.
[2] D. Suess, T. Schrefl, S. Fahler et al, ” Exchange spring media for perpendicular recording,” Appl. Phys. Lett., 87 (2005) 012504.
[3] D.Suess, J.Lee, J. Fidler, T. Schrefl, arXiv:0805.1674.
[4] J. G. Zhu, “Microwave assisted magnetic recording”, Paper B6, TMRC Conference, Minneapolis, 2007.

Figures:

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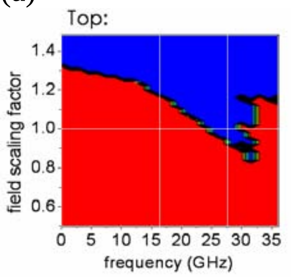
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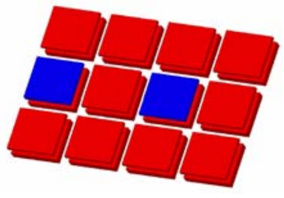</td>
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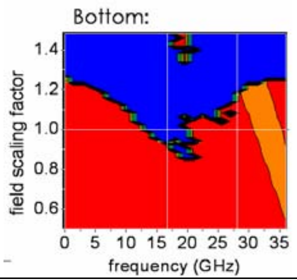
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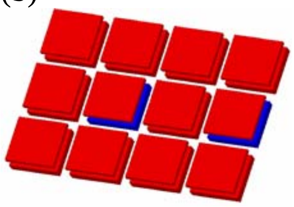</td>
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<td colspan="2">Fig 1: (a) Phase diagram of the top layer. The AC-field strength is 0.12T (b) For an AC-Frequency of 28 GHz only the top layer is addressed.</td>
<td colspan="2">Fig 2: (a) Phase diagram of the bottom layer. The AC-field strength is 0.08T (b) For an AC-Frequency of 16 GHz only the bottom layer is addressed.</td>
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