Graded exchange spring media based on FePt.

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ABSTRACT
We present data related to the advantages that Graded Exchange Spring Media (G-ESM) offer to tailor the coercivity of the fct-FePt films, which are the best candidates for the future recording media in excess of 1 Tbit/in^2. By varying the thickness and the anisotropy of the "soft" fcc-FePt we have achieved a reduction of the switching field from the value of 3.5 T for the hard single fct-FePt layer to a value less than 1 T, suitable for recording with existing GMR heads.

INTRODUCTION
Future recording media must have high anisotropy in order to beat the superparamagnetic limit due to the reduction of bit size in the sun-10nm range. A material with the best so-far properties as a candidate magnetic layer for perpendicular magnetic recording is the fct-FePt with anisotropy constants in excess of 10 MJ/m^3. The high coercivity field (H_c > 3T) of these materials makes difficult the writing process using the available magnetic write heads. Solutions to these problems are the Heat Assisted Magnetic Recording approach or a novel type of Exchange Spring Media (ESM) [1]. In the ESM media a magnetically hard layer (high anisotropy K_u) and a magnetically softer layer (lower anisotropy K_u) are strongly exchange coupled leading to structures with lower H_c thus lowering the write field requirements. A better approach for reducing more the writing field but keeping the thermal stability very high is the class of Graded Exchange Spring Media, which have been proposed as a new class of nanocomposite material appropriate for ultra high density recording media [2] (Goll, APL 2010, APL 2011). Graded ESM with a spatially varying anisotropy $K_u(z)$ offer improved characteristics in comparison to homogeneous, constant Hard / Soft bilayer media.

EXPERIMENTAL
Single and graded exchange spring media were prepared by magnetron sputtering from a single FePt target on single crystal MgO (001) substrate. First we deposited a single hard fct-FePt layer wit a thickness of 1- nm with a coercivity of 3.8 T . On top of such a film by changing the deposition temperature we deposited continuously, with the same sputtering conditions, a film of thickness up to 30 nm. With such a procedure we managed to change the anisotropy constant $K_u(z)$ reaching an fcc-FePt value when the terminal temperature was below 200 ^{0}C (Fig. 1.). We have prepared a series of samples by varying the $K_u(z)$ either by using stacks of FePt layers with different anisotropy constants – deposited at different substrate temperatures in a graded fashion or by co-depositing FePt at predetermined temperatures. This approach produces a monotonic gradient of the anisotropy constant through the thickness of the layer in a more controlled fashion with no interfaces.

RESULTS
In Fig. 1a the ideal graded ESM media is shown and in Fig. 1(b) a schematic of one bit of graded media is shown with $K_u(z)$ variation. In Fig. 2a the ideal and realistic structure is shown based on TEM results as in Fig. 2b. Lee et al. , using the model of Fig. 2a has calculated , using micromagnetic calculations and for different $K_u(z)$ profiles, and the results are shown in Fig. 4. In Fig. 5 we show the experimental data of our samples , which confirm the modeling results. The films were characterized using XRD, GID, TEM, AFM, MFM. The first results showed that the switching field is significantly reduced compared to single phase media, verifying the theoretical calculations [3, 4].

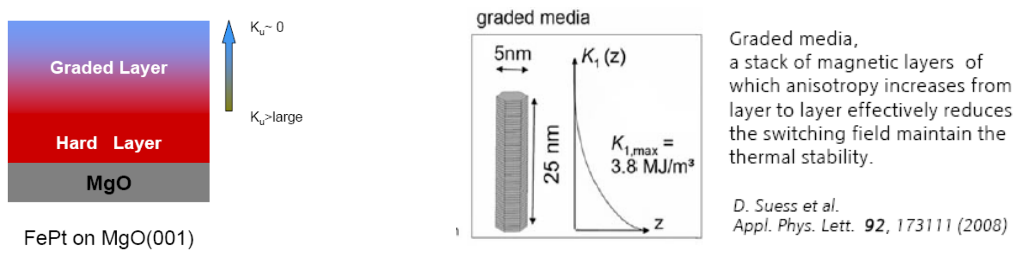
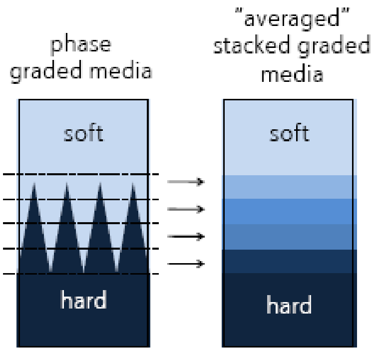


Fig 1. (a)Model graded ESM (left) , (b) Realistic structure of exchange spring media (right)



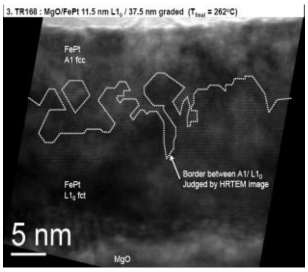
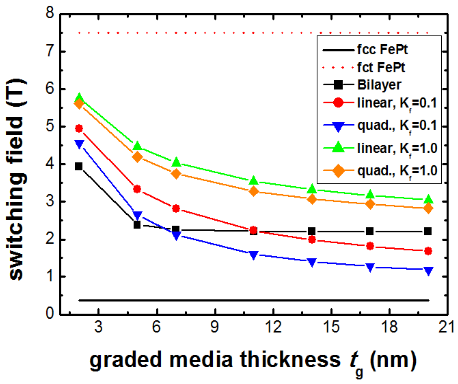


Fig 2. (a).The ideal and realistic structure (left picture)   (b). HRTEM-TEM image



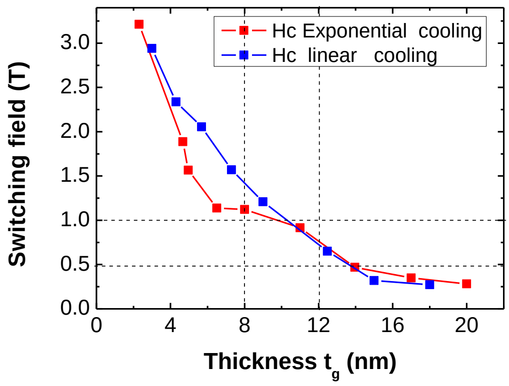


Fig 4. Variation of switching field with the exponential cooling temperature profile

Fig 5. Experimental data of linear and

CONCLUSIONS

In conclusion, it was shown that the phase graded media consisting of only two phases fct-FePt/ fcc-FePt can be used to tailor the coercivity of the hard fct-FePt films and considerably decreased the switching field by introducing rough interface between the two phases. By controlling the interface between the hard/soft and using various types of modification of the $K_u(z)$ we can optimize not only the switching field but also interdiffusion of the two phases, the pinning and nucleation fields.

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