Small-angle X-ray Scattering from Magnetic Clusters and Structural Grains in Magnetic Recording Media

Historically, areal density increases in longitudinal hard disk drive media technology have been driven by reduction of grain size. However, since its introduction in 2006, the perpendicular magnetic recording media grain size has remained more or less constant at around 9 nm. Perpendicular magnetic recording media consist of CoCrPt-based granular magnetic thin films, which are phase segregated with a non-magnetic oxide at the grain boundaries. Along with other improvements, the perpendicular geometry allows for a tighter packing of bits compared to longitudinal media and has resulted in a six-fold increase in areal density from 150 Gb/in^2 to 900 Gb/in^2 from 2006 until today without significant changes in grain size, but mainly driven by an increasingly complex exchange coupled composite (ECC) magnetic layer stack. To drive this technology to its sustainable limits in terms of areal density, a deeper understanding of the trade-offs between structural grain size and magnetic cluster size and their corresponding distribution is required. This understanding is especially important for the management and optimization of inter-granular exchange coupling, which could potentially inhibit any gains in areal density capability as grain sizes and grain boundary widths are reduced.

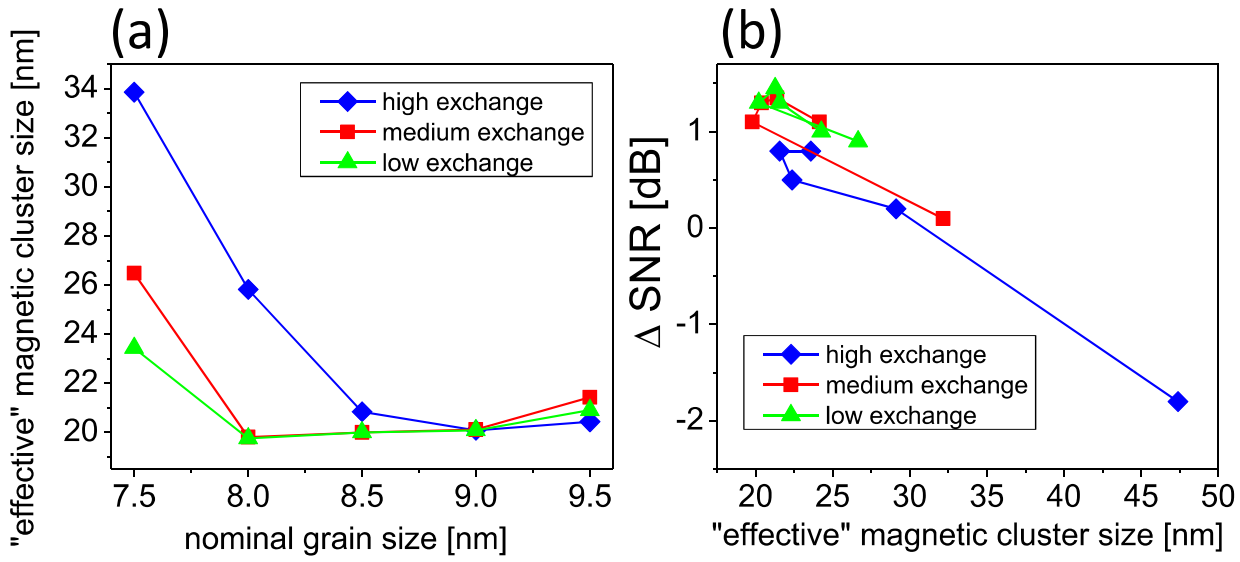

Fig. 1. (a) Variation of "effective" magnetic cluster size with nominal grain size in magnetic storage media characterized by low, medium and high intergranular exchange coupling. Both parameters were determined by small angle x-ray scattering at SSRL. (b) Correlation between effective magnetic cluster size and the signal-to-noise ratio determined from recording disk sister samples.

In this study, supported by the Department of Energy, researchers from SIMES and HGST have used Co L_3 edge transmission small-angle x-ray scattering at SSRL Beam Line 13-3 to probe the magnetic cluster size and the cluster size distribution for various magnetic storage media characterized by differing inter-grain exchange coupling (ranging from high over medium to low exchange in Fig. 1). X-rays can simultaneously probe magnetic cluster and structural grain sizes [1] (Fig. 1a) in a single experiment, even for proto-type recording media structures in early stages of the development. Fig. 1b clearly shows a distinct

correlation between a larger magnetic recording signal-to-noise ratio observed for the low exchange recording media.

These results show that this type of improvement is not a simple matter of shrinking the structural grain size, but instead can only be achieved by a careful tuning of intergranular exchange as the grain size is reduced.

Primary Citation

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References

1. T. Wang, V. Mehta, Y. Ikeda, H. Do, K. Takano, S. Florez, B. D. Terris, B. Wu, C. Graves, M. Shu, R. Rick, A. Scherz, J. Stöhr and O. Hellwig, "Magnetic Design Evolution in Perpendicular Magnetic Recording Media as Revealed by Resonant Small Angle X-ray Scattering", *Appl. Phys. Lett.* **103**, 112403 (2013), DOI: 10.1063/1.4820921.

Contacts

Olav Hellwig, HGST

Hermann Dürr, SIMES

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