

Micromagnetic study of nanostructured magnetic materials

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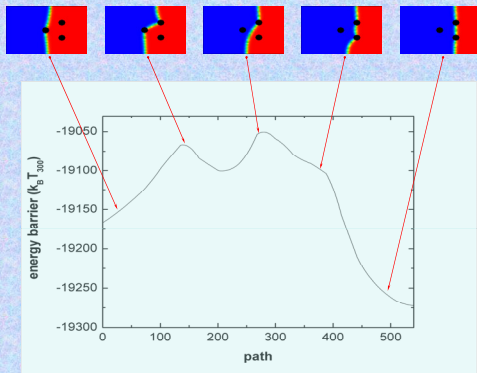


INTRODUCTION

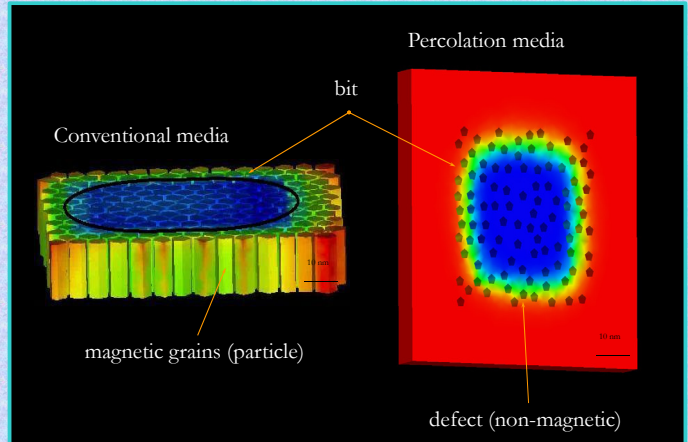
Nanostructured materials take on an enormously rich variety of properties and promise exciting advances in magnetic recording devices. The structure-composition-processing-magnetic switching relationships for these sub-100-nm-sized materials can be understood by employing numerical micromagnetic techniques. The thermal stability limitations and transition noise of perpendicular recording media are determined mainly by the grain volume and magnetocrystalline anisotropy. The challenge of terabit recording densities lead to new concepts, such as the pinning of domain walls in percolated media, where the grains are fully exchange coupled to each other. In this case the thermal stability is not determined by the grain volume, but by the energy barrier to overcome the domain wall pinning. Percolated perpendicular media with exchange-coupled grains allow large grain sizes for ultrahigh density recording, which is advantageous, especially for thermally assisted recording.

MICROMAGNETIC SIMULATION MODEL

For the micromagnetic simulations, we apply the finite element method to solve the Landau-Lifshitz-Gilbert equation for the calculation of the pinning field and the nudged elastic band method for calculating the energy barrier as described in 1 and 2. A very fine discretization of the finite element mesh between 1 and 2 nm was necessary to resolve the domain wall and the pinning behavior of the domain wall.



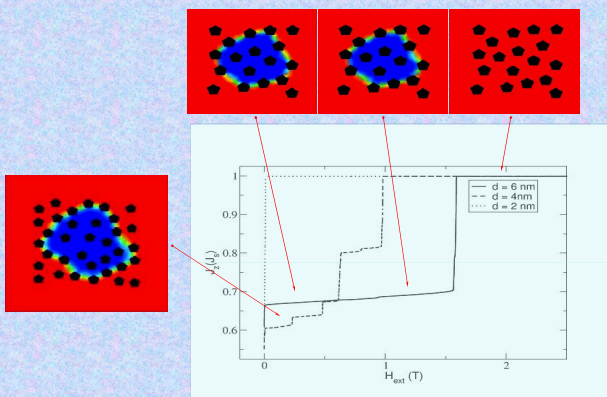
Energy along the minimum energy path that connects the initial state (left) and the final state (right). The defect diameter is 4 nm. The thickness of the media is 16 nm.



Plane view of the domain pattern during the application of an external field within a box of 20 x 20 nm² for the material parameter showing broad domain wall transition widths.

Thickness (nm)	Defect Diameter (nm)	DE (k _B T)
16	6	81.2
16	4	2.7
12	4	1.6
8	4	1.5

Energy barrier for thermally induced depinning of the initially formed domain wall.



Magnetization curve during the reversal process of the a bit for films with different defect sizes.

CONCLUSION

The numerical calculations of pinning field and energy barriers show the following requirements for percolation media. The randomly placed hole barriers should have a narrow distribution of the pinning fields in order to achieve a high thermal stability. The condition that the domain wall width is on the order of the defect size leads either to large defects or high K_u values. A large defect size will lead to a large transition width. High magnetocrystalline anisotropy will require high head fields and/or thermally assisted bit writing. For practical application, a compromise between transition width and writeability has to be found.

ACKNOWLEDGEMENTS

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2. R. Dittrich, T. Schrefl, D. Suess, W. Scholz, H. Forster, and J. Fidler, *J. Magn. Magn. Mater.* 250, 12 (2002).