Sol-gel assisted preparation of nanocomposite films for future ultra high density magnetic data storage device

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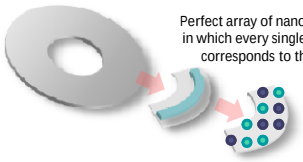
Abstract

For magnetic data storage application, significant progresses would be achieved if nanocomposite layers with high surface densities of nanomagnets could be prepared in a simple and reproducible way. Here we used block copolymer self assembly to create arrays of nanoperforations. These patterns are used as a template for the deposition of Co/Pt multilayers with out-of-plane magnetic anisotropy. Magnetic nanodots surrounded by a continuous magnetic film are obtained. We showed that domain walls are pinned on structural inhomogeneities given by the underlying nanoperforated template topography, which is highly promising as percolated magnetic media for high density data storage.

High density data storage device

Bit Patterned Media



Perfect array of nanomagnets in which every single domain corresponds to the BIT

TOP-DOWN TECHNIQUES

- ü *Long-range ordered arrays*
- o *Time consuming*
- o *Resolution > 25 nm*
- o *Cost effective*

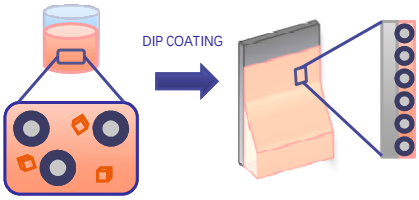
BOTTOM-UP APPROACH

- o *Short-range ordered arrays*
- ü *Easly accessible*
- ü *Resolution < 25 nm*
- ü *Low cost*

Percolated Perpendicular Media

Magnetic film on a substrate with perforations acting as pinning sites for magnetic domain walls

Patterning by bottom-up approach



Zirconia nanoperforated membranes were synthesized via a sol-gel based strategy [1] that involves nanotexturation of a substrate through solution deposition of zirconia precursors with block copolymer micelles. The block copolymer PB-PEO has been used as templating agent and $ZrCl_4$ as inorganic precursors. Thin films were elaborated by dip-coating at a constant withdrawal speed and controlled temperature and humidity in the chamber [2] . Calcination was performed at 500°C in order to decompose the organic part and lead the crystallization of the oxide matrix.

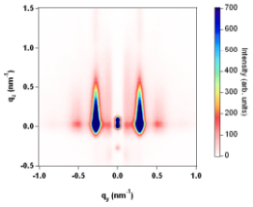
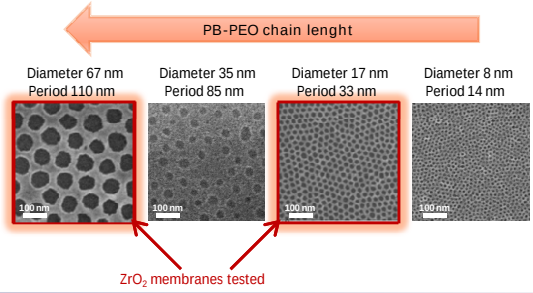
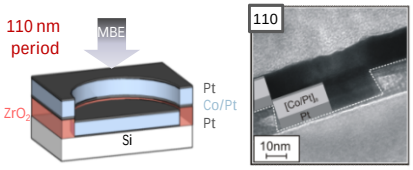


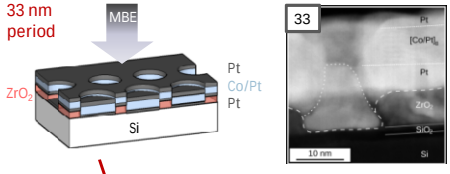
Figure ... shows a 70° tilted SEM of the ZrO2 revealing an highly ordered assembly of nanoperforations confirmed by the the presence of the two characteristics diffraction rods in the GI-SAXS pattern. A range of PB-PEOs can be used in order to obtain larger or smaller mesopore and tune the wall thickness. Longer PB chain leads to bigger pore size while PEO chain lenght influences the centre to centre distance. So far hexagonal lattice of pores was shown with diameter between 8 and 70 nm and period between 14 and 110 nm.

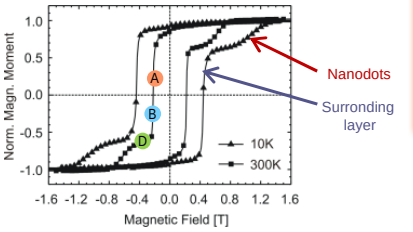


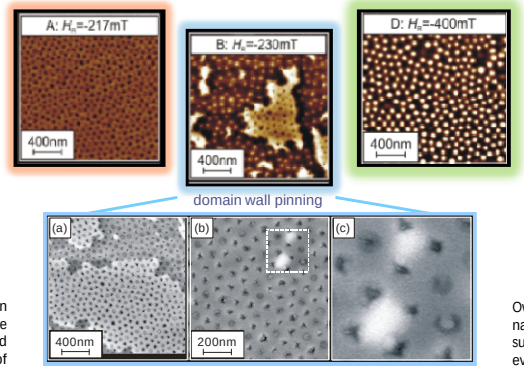
Magnetic arrays

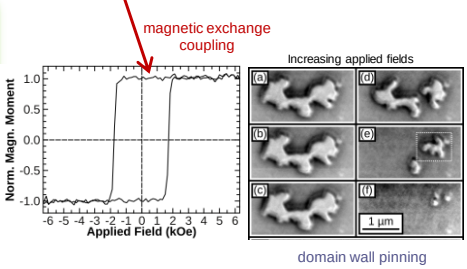


MFM image taken at remanence after exposure the sample to a reverse magnetic field of -400 mT MFM show a strong contrast coming from the nanodots which remain in their initial magnetization state pointing in the opposite direction compared to the surrounding film. MFM image taken at -230 mT suggests the presence of a strong domain wall pinning in the system. Superimposition of the topographical AFM and magnetic MFM images evidences that the domain wall is pinned at structural inhomogeneities surrounding individual nanoperforations.









From the hysteresys loop the first sharp magnetization reversal can be related to the continuous magnetic film surrounding the nanoperforations (coercive field of 250 mT), whereas the second part at higher fields represents the switching of the array of magnetic nanodots [3] .

Owing to the structural properties at the edges of the 17 nm size nanoperforations, exchange coupling between the nanods and the surrounding film is shown. However magnetic investigations and HR-MFM evidence the presence of a strong pinning of the magnetic domain walls [4].

Conclusions

An organic/inorganic self-assembly technique using block copolymer micelles was applied to create arrays of nanoperforations with period of 110 nm and 33 nm. This patterned substrate was used as a template for the deposition of Co/Pt multilayers with out-of-plane magnetic anisotropy. Detailed MFM analysis revealed the presence of strong pinning of magnetic domain walls at the edge of the nanoperforations.Therefore, the approach of pattern formation presented in this work is considered to be promising to create a percolated magnetic media, which is attractive for the future generation of magnetic storage devices.

[1] M. Kuemmel et al., A chemical Solution Deposition Route to Nanopatterned Inorganic Materials Surfaces, *Chem. Mater., vol. 19, pp. 3717-3725, 2007.*
[2] M. Faustini et al., Preparation of Sol-Gel films by dip-coating in extreme conditions, *Journal of Physical Chemistry C, Vol. 114, 2010, pp. 7637-7645.*
[3] D. Makarov et al., Magnetization Reversal in Arrays of Magnetic Nanoperforations *IEEE Trans. Magn. 45, (2009) 3515.*
[4] C. Schulze et al., Magnetic Films On Nanoperforated Templates: A Route Towards Percolated Perpendicular Media, *Nanotechnology, submitted.*