Networks of Nanomagnets Fabricated via Stenciling and Magnetron Sputtering to Investigate Nanoscale Magnetic Switching

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The development of magnetologic devices[1] requires a thorough understanding of the *magnetic reversal phenomena* (switching) of *nanofabricated magnetic arrays*. We use *magnetic force microscopy* (MFM)[2] and *transmission electron microscopy* (TEM), on the same magnetic networks, to assess the importance of the *microscopic structure*/*chemical composition* on the magnetic *switching field distribution* (SFD).

Adapting the resist-based lithographic fabrication methods to atypical material systems such as patterned media on TEM membranes is an intricate task. Thus we employed *stenciling* as the strategy to fabricate indexed permalloy (Py) nanoscale arrays on ultrathin silicon nitride (SiN) membranes. Stencilling is a resist-free, direct replication process that can be performed in high or ultra high vacuum and therefore highly suitable for parallel prototyping of fragile surfaces.

The miniature stencil-masks we used during the deposition process feature ordered arrays of nano-apertures, prepared by focused ion beam (FIB) milling. The apertures were designed having rectangular shapes, width aspect ratios (length/width) ranging from 3:1 to 6:1 and various spacing. Using DC magnetron sputtering in a low argon background pressure (< 20mTorr) the stencil motifs were replicated straightforward onto TEM membrane windows used as substrates. The stencils are reusable and we reached the fabrication of elliptical structures with widths down to 50nm and spacing as small as 50 nm.

MFM measurements carried out in a custom-built vacuum MFM microscope with in-situ, in-plane magnetic fields, allowed us to identify different magnetic switching mechanisms related with the structures' aspect ratios. We also traced the "early" and the "late" switchers. Subsequent TEM imaging was focused on investigating their microstructure as to identify structural/compositional variations which may induce differences in their performance and broaden the SFD. We discuss the fabrication process, permalloy microstructure/composition and their potential impact on the structures' magnetic reversal.

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[1] A. Imre, G. Csaba, L. Ji, A. Orlov, G.H. Bernstein and W. Porod, Science **311**, 205 (2006)
[2] X. Zhu and P. Grutter, MRS Bulletin, **July**, 457 (2004)