Enhancement and correlation of MFM images: effect of the tip on the magnetic configuration of patterned Co thin films

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A technique of numerical treatment of magnetic force microscopy (MFM) data matrices has been exploited to enhance the quality of raw MFM images of patterned Co thin films obtained by Electron Beam Lithography on RF sputtered 30-nm-thick Co samples. The pattern consists of chains of elliptical cylinders whose major axis is around 2.5 μm and whose minor axis is around 0.5 μm (aspect ratio 5:1). The magnetic-image numerical treatment was outlined in a previous paper [1]. In this work, a new differential approach is proposed: two or more MFM images of the same surface area of a soft ferromagnetic material submitted to different magnetic fields H are examined, and the different arrangements of the local magnetization, as emerging from contrast differences in MFM images, are analyzed as functions of H. It is shown that this differential approach is able to account for the effect of the MFM tip on the magnetization of the investigated soft magnetic material, when the tip is coated by both a low-coercivity and by a high-coercivity material . The patterned Co samples used to demonstrate this method have been demagnetized before each MFM scan either in plane or out of plane by applying an alternate field of progressively small absolute value.

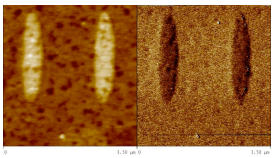

Figure 1: *AFM (left) and MFM (right) raw images at H = -100 Oe; magnetic field applied along the major axis of the elliptical elements.*

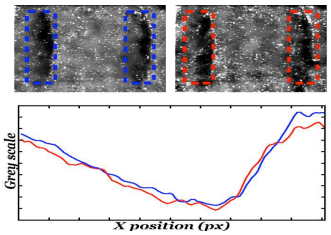

Figure 2: *Differential enhanced filtered MFM matrices: 0 / -100 Oe (left) and 0 / 100 Oe (right). The two curves (bottom blue and red) show a regional integration of the tip-sample interaction profile (corresponding to dashed areas, blue and red).*

When the tip coercivity is much lower than H, the magnetic contrast found in correspondence of Co elements mainly arises because of the switching of the tip magnetization; after performing a line integration along the element width in order to increase the signal-to-noise ratio, it becomes possible to get information about the tip-induced magnetic signal (which is usually convoluted with the sample-induced one) by subtracting the switched-tip-frame from the unbiased (H = 0) frame. When the sample is not affected by H, fully matched profiles of the magnetic contrast across each Co element may be extrapolated. Numerical elaborations of images taken with a high-coercivity tip will be presented and commented also.

[1] A. Chiolerio et al., Journal of Magnetism and Magnetic Materials 320 (2008) e669-e673.

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