TAILORING ANISOTROPY IN A MAGNETIC ARRAY BY CHANGING THE ARRAY SHAPE

R. Álvarez-Sánchez, J.L. Costa-Krämer, and F. Briones
Instituto de Microelectrónica de Madrid, IMM (CNM-CSIC)
Isaac Newton 8, PTM, 28760 Tres Cantos, Spain
ras@imm.cnm.csic.esT

When reducing the size and separation of magnetic array elements to the nanoscale, long range magnetostatic interactions might become decisive in the magnetic performance. At element separation distances below a critical threshold both the element and the array shape must be taken into account. Previous works[1,2,3] have shown experimentally that the magnetic response (measured by Magneto-Optics) of small magnetic elements stacked into arrays depends on array parameters and that below a interaction threshold even the individual element magnetization reversal mechanism might change. Furthermore, by changing suitably the array shape within the interaction range magnetic anisotropies can be induced. This can be termed lattice shape anisotropies, to be considered in addition to conventional element shape anisotropies.

Figure 1 shows how an array of Co elements (40nm thickness) recovers, as seen in the remanence vs angle dependence, the intrinsic material uniaxial anisotropy for interelement separation distances of 200nm. The individual shape dominates the magnetization processes at above 1μm separations. Beyond this value, the element shape masks the intrinsic anisotropy. Below, the interactions, and consequently the lattice shape, have to be taken into account.

This effect can be studied from a theoretical point of view using an exact analytical model for the study of shape anisotropy in arrays of orthorhombic magnetic elements equivalent to the one developed by Tsymbal[4, 5] (Fig.2 inset shows the geometrical parameters) to predict the behaviour of the induced lattice shape anisotropy. As a first approximation the model assumes that all elements within the array behave identically and that the magnetization is homogeneous. Trying to make quantitative estimations of lattice anisotropy values, we show in Fig.2 that the same anisotropy obtained with a square array of rectangular elements can be obtained with a rectangular array of square elements.

References:

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Figures:

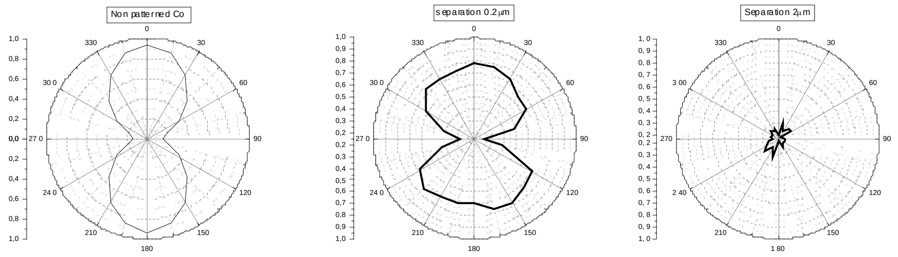

Fig. 1: Polar plots of remanence for non-patterned Co, a square array of 2µm edge square elements with 200 nm interelement separation and a square array of 2µm edge square elements with 2µm interelement separation. As interelement separation increases, the Co uniaxial anisotropy is masked.

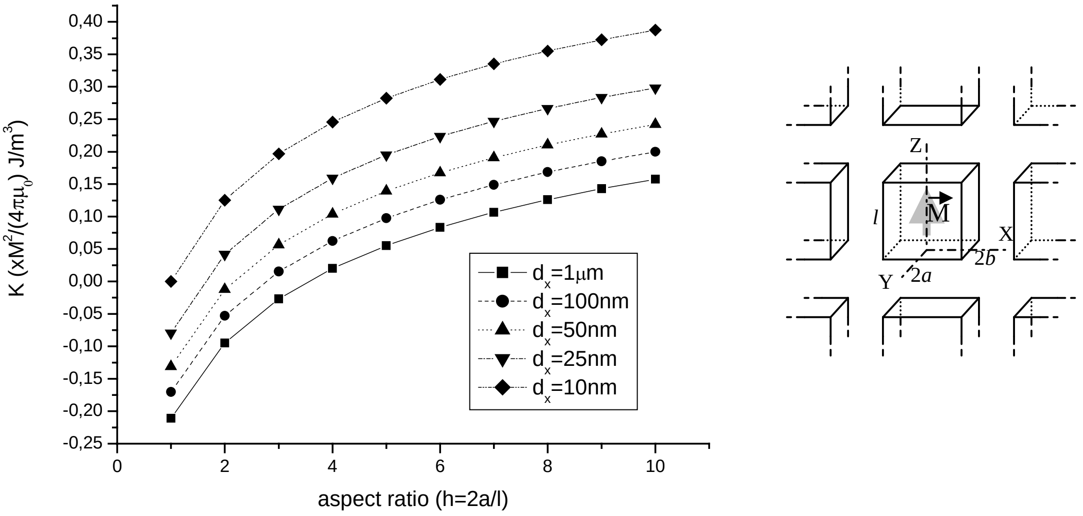

Fig. 2: Subtraction of shape anisotropy of rectangular elements of aspect ratio h=2a/l (l=100 nm) in a square array of 10nm interelement separation and square elements in a rectangular array. The conditions of aspect ratio and interelement separation in which K=0 provides the aspect ratio of a rectangular element in a square array of 10 nm interelement separation that induces the same anisotropy than a rectangular array of 100 nm square elements with interelement distances 10 nm (Z axis) and d_x (X axis). The inset shows the geometrical parameters of the considered array of orthorombical $l \times 2a \times 2b$ magnetic elements. All elements are monodomains with identical behaviour

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