Nanomagnets

Personnel

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We are using Interference Lithography (IL) to produce large-area arrays of 'nanomagnets' with spatial periods of 100 - 200nm. These particles have been made by electrodeposition, by evaporation and liftoff, or by etching of a sputtered film. We are exploring the switching mechanisms of the particles, the thermal stability of their magnetization, interparticle interactions, and assessing their suitability for various data-storage schemes. The collective behavior of the arrays can be measured using magnetometry and compared with the behavior of individual particles using magnetic-force microscopy in order to understand how the behavior of one magnet is affected by its neighbors. From such data, the intrinsic variability between particles can be determined, and related to the microstructure. For instance, we found that the reversal in 30 nm-diameter polycrystalline Ni particles is governed by the grain structure.

We have also performed micromagnetic simulations to explore the remanent magnetic states, and mechanisms for magnetization reversal in these structures. Small particles have near-uniform magnetization states, while larger ones develop more complex structures such as magnetization vortices or domain walls. Good agreement between model and observed remanent states is obtained, taking the shape and crystal orientation into account.

These particle arrays have potential uses in 'patterned media', in which each particle stores one bit of data according to its magnetization direction.

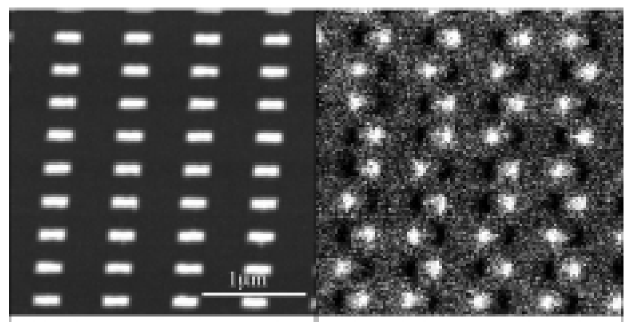

Fig 1: An array of NiFe rectangular 80nm x 240nm x 10 nm thick elements. The left picture shows an atomic force micrograph in which the elements have lighter contrast than the substrate. The image on the right is a magnetic force image of the same array after a.c. demagnetization, which randomizes the magnetic state. Each element acts as a single-domain magnet, and shows as an adjacent light and dark dot, which represents the north and south poles.

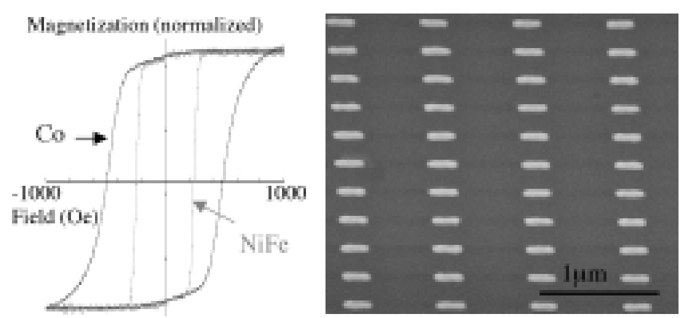

Fig. 2: SEM image of Co elements, 90nm x 200nm x 10 nm thick, made similarly to the NiFe elements in the previous figure. The hysteresis loops of both the NiFe and the Co elements are shown superposed on the right. The NiFe elements are quite uniform and switch their magnetization over a small field range, while the Co elements reverse over a wide field range, as a result of microstructural variability.