Challenges in nanomagnetism - Confined systems

Properties of thin film nanomagnets made using block copolymer lithography

C. Ross, MIT

An area of great interest is the fabrication and magnetic properties of arrays of nanomagnets for patterned media. These need to have high densities (i.e. periodicity << 50 nm) and be formed over large substrate areas. Self-assembled block copolymer lithography is a good way to fabricate such structures. Block copolymers consist of polymer chains made from two chemically distinct polymer materials. These can self-assemble to form small-scale ordered patterns whose size and geometry depend on the molecular weights of the two types of polymer and their interaction. We have been using block copolymers as templates for the formation of magnetic particles, by selectively removing one type of polymer and using the resulting template to pattern a magnetic film. The arrays show strong effects of interparticle interactions, and magnetoresistance [1]. Furthermore, the 2D arrangement of the structures on the surface can be controlled by shallow surface features, allowing long range order to be imposed on the array [2], and this may enable the formation of practical data storage devices such as patterned hard disks. The challenges in this work are to understand the domain states of these small (<25 nm diameter) single or multilayer thin film elements; the reversal mechanisms and the dynamic behavior on sub-ns timescales; the interactions between particles and between layers in a multilayer particle; and the origins of variability between nominally identical particles; and to relate these phenomena to the array geometry, the microstructure, the edge, interface and surface structure, the presence of surface oxides, and shape and magnetocrystalline anisotropy.

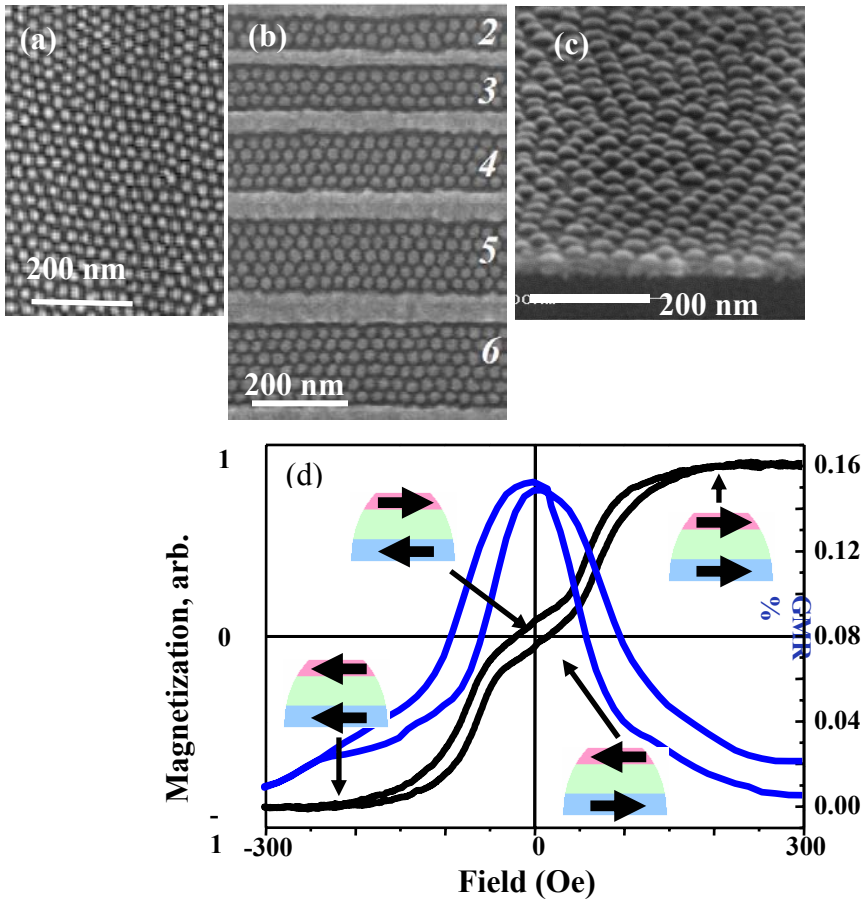

Figure 1. (a) Self assembled block copolymer on a smooth substrate, showing lack of long range order. (b) In shallow grooves, the polymer forms long range ordered structures. (c) Array of Co 'dots' made by block copolymer lithography. (d) Magnetization (black) and magnetoresistance (blue) of an array of 35 nm diameter dots made from a CoFe 3.3 nm/Cu 6 nm/NiFe 4.5 nm multilayer. The multilayer structure is preserved during the fabrication process, and the data illustrate the separate switching of the NiFe and the CoFe layers. The insets show the magnetic state of the dots at each part of the hysteresis loop: the pink layer represents the CoFe and the blue the NiFe.

References:

1. J. Cheng, W. Jung, C.A. Ross, "Magnetic nanostructures from block copolymer lithography: hysteresis, thermal stability and magnetoresistance", *in press,* Phys. Rev. B (2004)
2. J. Cheng, C.A. Ross, A. Mayes, "Nanostructure Engineering by Templated Self-Assembly", *in press,* Nature Materials (2004).