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Magnetic Properties of Half Ring NiFe Micron Structures with Exchange Bias Layer

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Modern lithography technique makes micron or nanometer structuresmore accessible. As the size of a magnetic structure is reduced to the single domain length scale, magnetic moments reversal can be studied in details. However, how to measure magnetic properties of individual structures poses challenge to experimentalists.

Arrays of half-ring NiFe and IrMn/NiFe structures were fabricated by e-beam lithography and lift-off technique. The outside diameter was fixed at 2 micron, line widthvaried down to 0.05 micron, and the thickness kept at 20 or 30 nm. The sample pitch was 4 micron. Magneto-Optical Kerr Effect was used to measure the hysteresis loops. Magnetic Force Microscopy with in-situ field was used for domain wall observation. Micro-magnetic simulation program, OOMMF, was used to simulate the moment reversal. For single films, the shape anisotropy dominates. The coercive fields of, for example, 0.4 micron wide and 30 nm thick samples were 250 Oe and 150 Oe when the field was applied along the long and short axes, respectively. This indicates a vortex domain wall can be formed easier at the arc than at the ends of the half ring. For double layer structures, the direction of the uni-direction anisotropy can be controlled by field-cooling the sample after elevated annealing temperatures (250 to 450 degree C). The hysteresis loops were shift to one side due to the exchange coupling between antiferromagnetic IrMn and the ferromagnetic NiFe. The exchange field strength does not follow a cosine curve when the external field was rotated in the sample plane. It can be attributed to the competition between the shape and the exchange anisotropies.

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Observation of Current-Driven Domain Wall Motion in L-shaped NiFe Nanowires

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Current-driven domain wall motion in magnetic nanowires has attracted much research interests due to its basic physical mechanisms involved and its potentials in applications such as magnetic logic [1] and high-density storage devices [2]. Compared to conventional magnetic devices using external magnetic field for the encoding of information, domain wall motion or magnetization reversal by electrical currents can be a promising alternative encoding method because of lower power consumption, reduction of magnetic interference, and simple device structures. Although many research groups reported on the domain wall motion triggered by an electric current, the underlying theory of the interaction between spin currents and magnetic domain walls is still controversial [3-4].

In this presentation, the magnetic force microscopy (MFM) imaging of the current-induced domain wall motionin NiFe nanowires will be reported. A diamond-shaped pad that acts as a domain wall injector is connected to one end of L-shaped nanowires while the other end is sharply pointed for the annihilation of magnetic domain walls. 200nm wide L-shaped wires with 20nm-thick NiFe were patterned by using electron-beam lithography and a subtractive ion beam milling procedure.

Both low and high moment probes were used for the MFM observations in the experiment. Although high moment probes showed high MFM signals during the measurements, the probe's stray field caused the manipulation of domain walls in the nanowires. In this experiment, the critical current density of about 2×10^8 A/cm^2 was observed.

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