Magnetic transmission X-ray microscopy of field-driven magnetization processes in Permalloy structures

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Domain walls in lithographically patterned magnetic nanowires have become studied intensively recently, not least because of the prospect of non-volatile shift register memory [1,2]. The wires are often made of Permalloy ($Ni_{81}Fe_{19}$), which has low magnetocrystalline anisotropy and magnetostriction so that its magnetization behavior is dictated by the wire geometry. Domain walls can be introduced to nanowires at relatively low magnetic fields using a large area 'injection pad' on the end of a wire [3]. This is well understood for linear fields but many experiments and applications use 2D magnetic fields [1]. Imaging of domain and domain wall behavior has proven essential in gaining an understanding of the magnetic response to applied field and injected current. Here, we use magnetic transmission X-ray microscopy (M-TXM) [4] to observe field-driven processes in Permalloy structures fabricated on X-ray transparent Si_3N_4 membranes. M-TXM is well suited to this form of analysis since the X-rays are insensitive to magnetic field and spatial resolution of ~ 15 nm can be achieved [5].

M-TXM images in full hysteresis loops of sub-micrometer Permalloy samples with various shapes (circles, squares and hexagons) and thicknesses t down to 10nm were recorded. The switching of 2 µm × 3 µm injection pads attached to nanowires of different width (t = 20 nm) was studied while under transverse (H_t) and axial applied magnetic fields. The domain configuration in the pads is highly sensitive to H_t, which results in changes to the axial field required to inject a domain wall. In contrast to previous work [6], this field increases with H_t. Finally, we image a transverse domain wall in a 200 nm wide wire and observe field-induced propagation. Supported by the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

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