Nonmonotonic length dependence of switching field of nanolithographically defined single-domain nickel and cobalt bars (abstract)

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Previously, the switching field of nanolithographically defined single-domain permalloy and nickel bars was found to increase monotonically as the bar aspect ratio increases[1] or as the bar width decreases.[2] In this work, we will show, for the first time, that when the bar width is fixed, the switching field of nanolithographically defined single-domain nickel and cobalt bars changes nonmonotonically with the bar length (hence the aspect ratio). The isolated Ni and Co bars were fabricated using electron-beam lithography and a lift-off process, and have a thickness of 35 nm, a fixed width of 100 nm, and a length varying from 200 nm to 5 μm. The magnetic force microscopy (MFM) showed that all the as-fabricated bars, except for the Ni bars with a length less than 500 nm, are single domain. The switching field of the single-domain bars was found to increase with the bar length first, then decrease after reaching a peak. The peak switching field and corresponding bar length are 640 Oe and 1 μm for Ni, and 1250 Oe and 2 μm for Co. This behavior, which clearly deviates from Stoner-Wohlfarth model, suggests that two different mechanisms should be responsible for the magnetization reversal process in different bar lengths. When the bar length is small, the exchange energy can be much larger than the magnetostatic energy to keep the bar switching quasicoherently and the switching field increases with the bar length. However, when the bar length is large, the exchange energy cannot overweigh the magnetostatic energy for quasi-coherent switching and therefore the lowest switching energy state would be incoherent switching which involves multidomain (or vortex) reversal leading to an decrease of switching field. The detailed analysis will be presented in the paper. *© 1996 American Institute of Physics.* [S0021-8979(96)82208-4]

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[1] J. F. Smyth *et al.*, J. Appl. Phys. **69**, 5262 (1991).

[2] M. S. Wei and S. Y. Chou, J. Appl. Phys. **76**, 6679 (1994).

Ultramicro fabrications on Fe-Ni alloy films using electron-beam writing and reactive-ion etching (abstract)

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Microfabrication techniques are successfully used for semiconducting materials, while they are limited for the application to magnetic materials. For the magnetic materials, useful RIE (reactive-ion-etching) process that is essential for high-resolution microlithography has not yet been successful. In this work, RIE method useful for permalloy (80%Ni-4.5%Mo-Fe) has been newly constructed. High-resolution electron-beam writing was followed by the RIE process, leading to 250 nm line and space patterns in the permalloy film with 10 nm accuracy. In order to achieve a high-resolution electron-beam writing, amorphous carbon film was use between the resist layer and SiO_2 film overlaid on the permalloy film. There are four levels in the process. Most critical step in the fabrication of magnetic material is RIE process using a rf discharged plasma of NH_3-CO mixed gas. Maximum etching rate of 35 nm/min and highly anisotropic etching for the permalloy was obtained at the composition of 50 mol % NH_3-CO at the pressure of 2.4×10^{-3} Torr. The etching selectivity ratio of permalloy to SiO_2 employed as a mask was about 10. By this method, nanostructures of permalloy with highly anisotropic profile were fabricated. This method shows prominent features still for Co-Cr alloy films. *© 1996 American Institute of Physics.* [S0021-8979(96)80608-X]

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