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Reversal mechanisms and defects in perpendicularly magnetized nanostructures

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The problem of switching field distributions (SFDs) is currently plaguing developing technologies which rely on uniform arrays of magnetic nanostructures such as bit patterned media, magnetic random access memory (MRAM) and spin-torque oscillators. Most of these technologies are shifting towards the use of perpendicularly magnetized materials due to the increased device performance and thermal stability that can be achieved. SFDs in such perpendicularly magnetized nanostructures can result from dot-to-dot interactions and size distribution, but is largely dominated by material defects [1- 4]. Such defects can arise from both the material deposition process, and post-deposition processing that occurs during nanofabrication. By comparing nanostructures fabricated by deposition on pre-patterned wafers to those fabricated by ion milling of continuous films, we show that the anisotropy of the edge region can be greatly different in each case. The size, temperature, and angular dependences of the reversal field indicate that the reversal mechanism also differs. In contrast to fabrication induced defects, microstructural variations manifest themselves as a random distribution of local anisotropies. We studied the anisotropy distribution in patterned elements by imaging the localized reversal of low anisotropy regions and mapping these sites as a function of applied field using MFM imaging and TEM. In addition, we used simulations to show the effect a small localized region of lower anisotropy material (such as a grain) has on the reversal field of the entire nanostructure. We find that the reversal field depends on both the relative anisotropy of the defect to the film, as well as, the location of the defect within the structure.

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