Effects of magnetostatic interaction between two single-domain cobalt bars on crystal anisotropy and switching field (abstract)

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Understanding the magnetostatic field effects of a single-domain particle on its neighbors during thin film deposition and magnetic recording is essential to the development of magnetic recording media. Here, we present a unique study of such effects using nanofabrication technology and magnetic force microscopy (MFM). We fabricated pairs of single-domain cobalt bars. Each bar is 35 nm thick, 50 nm wide, and 1 μm long. The twin bars were oriented side-by-side on a silicon substrate with a spacing that varied from 50 to 1000 nm. In fabrication, a resist template was first created on a silicon substrate, followed by e-beam evaporation of cobalt into the bar-shaped openings of the template as well as on the top of the template. Then, the resist was dissolved making the cobalt on top of the template lift off. MFM showed that as-fabricated bars are single magnetic domain. We polarized the magnetic moment of the twin single-domain bars in the same direction and measured the magnetic field needed for the following three cases: (a) switching the magnetization direction of only one of the twin bars, H_a; (b) switching both bars, H_b; and (c) switching one bar after the other bar was physically removed by a nanotechnique, H_c. Two important facts can be seen. First, for a given bar spacing, $H_a < H_c < H_b$. The difference is due to the demagnetization field of the neighbor which is on the order of 150 Oe depending upon the bar spacing. Second, all three switching fields decrease significantly as the bar spacing becomes larger. For example, H_c is 2050 Oe for a 300 nm bar spacing and 1700 Oe for 1000 nm spacing. The spacing dependence of H_c clearly indicates that the intrinsic switching field of a bar has been significantly affected, during the cobalt deposition, by the demagnetization field of its neighbors. One explanation is that as soon as the first few atomic layers of cobalt were deposited into a nanoscale bar shaped opening in the resist template, a single domain is formed immediately creating a magnetostatic field. This field forces the c axis of the cobalt that was later deposited into the neighboring bar to align with the field, therefore enhancing the crystal anisotropy and intrinsic coercivity of the neighboring bar. This study implies that a small topology variation on a magnetic disk substrate may cause a large local coercivity variation due to the enhancement of crystal anisotropy and coercivity induced during the deposition by the demagnetization field of neighboring single-domain particles. [S0021-8979(96)43508-6]