Magnetization Dynamics in Ultrahigh-Density Magnetic Recording

R. SKOMSKI, J. ZHOU, D. J. SELLMYER, Department of Physics and Astronomy and Center for Materials Research and Analysis, University of Nebraska, Lincoln, NE — Thermally activated magnetization reversal is a key consideration in the development of magnetic recording materials with ultrahigh densities. We consider the onset of magnetization reversal (nucleation) and describe the magnetization by a Langevin model, where the magnetization dynamics is realized by random thermal forces. The exchange, anisotropy, and Zeeman energies are expanded into powers of a small perpendicular magnetization component, and the dynamics reduces to a time-dependent superposition of normal modes. In the Stoner-Wohlfarth (SW) model, the approach reproduces the Arrhenius-Néel-Brown law \( \tau = \tau_0 \exp(E_a/k_B T) \) with an approximate energy barrier \( E_a \) and a particle-size dependent constant \( \tau_0 \). The same is true for the micromagnetic approach, where the local micromagnetic parameters such as \( K_1(r) = \langle K_1(r) \rangle \) give rise to nonuniform magnetization modes in inhomogeneous and interacting particles. However, both the coercivity \( H_c \) and the energy barrier \( E_a \) are smaller than the SW predictions. A further reduction of \( H_c \) and \( E_a \) is obtained by taking into account local anisotropy fluctuations of the type \( \langle K_1(r)^2 \rangle - K_1(r)^2 \). This reduction corresponds to fluctuating energy barriers, and establishes a particle-shape and materials-dependent upper limit to energy barriers in very small particles.

\(^1\)This research is supported by NSF MRSEC, DOE, INSIC, and CMRA.

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Date submitted: 30 Nov 2005

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