Exchange-bias effect in core-shell nanoparticles with non-spherical shape and rough interfaces

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We study the isothermal magnetic hysteresis of nanoparticles with FM core - AF shell morphology for various sizes and different shapes, in order to elucidate the sensitivity of the exchange bias effect on the shape of the particles and the structural imperfections at the core-shell interface. We use classical Heisenberg Hamiltonian with different local anisotropy terms for the core, the shell and the surface. The field-cooled process and the isothermal hysteresis loop are simulated implementing the Metropolis Monte Carlo algorithm. The coercive (H_C) and exchange bias (H_{eb}) fields for spherical and cubical nanoparticles with similar nominal sizes are compared. At low temperatures ($T << K_{1FM}$), we show that (i) cubical particles exhibit higher coercivity and lower exchange bias field than spherical ones, owing to the lower number of uncompensated spins (N_{unc}), and (ii) with increasing interface roughness, the differences between spherical and cubical particles are gradually smeared out.

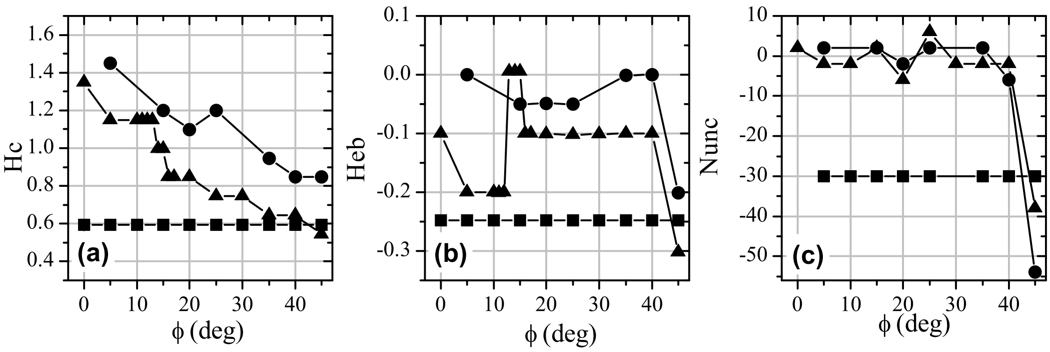

Figure 1: Dependence of (a) the coercive field, and (b) the exchange-bias field on the crystallographic orientation of the underlying SC lattice for two cubical particles (circles: $R_{ext} = 11a, R_c = 8a$, triangles: $R_{ext} = 8a, R_c = 5a$) and a spherical particle (squares: $R_{ext} = 11a, R_c = 8a$). The z-axis is taken along [001], the x and y-axes are rotated by the polar angle ϕ with respect to the [100] axis. The number of uncompensated spins (N_{unc}) depends on the polar angle ϕ as shown in (c).

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