SURFACE AND EXCHANGE ANISOTROPY IN A NANOGRANULAR Fe/FeOXIDE SYSTEM

D. Fiorani[1], L. Del Bianco[2], A.M. Testa[1]

[1]ISM - CNR, Area della Ricerca di Roma, Montelibretti (Roma), Italy.
[2]INFM and Dip.to Fisica, Università di Bologna, I-40127 Bologna, Italy.

Nanostructured magnetic materials are generally characterized by the coexistence of two or more phases, magnetically and/or structurally different, modulated on the nanometric scale. The macroscopic magnetic behavior of these nanocomposite materials is determined by the size, structure and morphology of the constituent phases and also by the type and strength of magnetic interaction between them [1]. In many cases, such systems can be properly described as collections of nanoparticles, or nanograins, dispersed in a matrix (nanogranular materials). Surface and interface effects, which are strongly dependent on the particle size and its distribution, give an important contribution to the total anisotropy of nanogranular systems. Moreover, in presence of interparticle interactions, the characteristics of the medium in which the particles are embedded and its ability to transmit exchange interactions have to be taken into account [2].
In this presentation, the mechanisms of inter-phase magnetic coupling in the nanogranular Fe/FeOxide system are described. The samples were obtained by compacting oxide-layered Fe particles, with mean size of the Fe core (D) varying from 6 to 15 nm, prepared by inert gas condensation and oxygen passivation. Zero-field-cooled and field-cooled magnetization vs. temperature and magnetic field and magnetic relaxation measurements were carried out in the 5-250 K temperature range. The results are explained in terms of the coexistence of two magnetic components [3]: a quasi-static ferromagnetic component (the Fe particles) and a relaxing one (regions of the structurally and magnetically disordered oxide matrix). The peculiar magneto-thermal behavior mainly originates from the exchange coupling between Fe and oxide phase: the coercivity (H_C) and the exchange field (H_{ex}) strongly increase with reducing temperature below T ~ 150 K, following the freezing of the oxide region moments. Below T ~ 20 K, the freezing of the oxide moments in a *cluster-glass-like* state is almost complete and the interplay between matrix-particle exchange coupling and particle-particle dipolar interactions results in a frozen state for the whole system. At T = 5 K, H_{ex} increases with decreasing D, revealing that exchange anisotropy effects at the particle/matrix interface are more important when the surface to volume ratio of the particles is larger.
In a sample with D = 6 nm, we have observed a strong dependence of H_{ex}, H_C and the remanent magnetization (Mr), measured at T = 5 K, on the cooling-field (H_{cool}). Both Mr and H_{ex} increase up to H_{cool} = 4 kOe. For higher H_{cool}, Mr reaches a plateau value of ~30 emu/g whereas H_{ex} decreases monotonously down to ~250 Oe after cooling in a field of 50 kOe. The results are explained considering that, on varying H_{cool}, different frozen magnetic configurations of the system at T = 5 K are selected, allowing the tuning of H_{ex}, H_C and M_r over a wide range of values.
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References

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