Nanocomposites and nanomaterials

Low temperature coercivity in the oriented ensembles of single-domain magnetic nanoparticles

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The magnetization reversal process in the oriented ensembles of single-domain nanoparticles, which are in superferromagnetic state, was investigated both, experimentally and theoretically. The experimental investigations were performed, using vibration sample magnetometry technics, and the hysteresis loops of the nanogranular composite Co/Al_2O_3 were obtained and analyzed. The theoretical investigations were related with modified Monte Carlo simulation of the ensemble of interacting single-domain nanoparticles with oriented anisotropy. The above mentioned modification, proposed by us, allows the correlated reorientation of the ensemble as a whole.

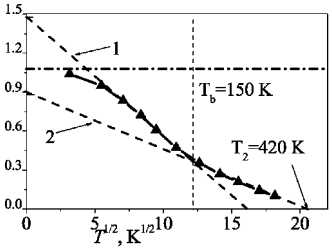

Fig.1. experimental values of coercive field, H_C, built in $T^{1/2}$ coordinates. Dashed lines 1 and 2 – linear approximation, described in the text. Experimental dots: ▲- the value of H_C for magnetization along easy anisotropy axes of the ensemble; dash-dotted line shows the approximate value, to which the coercivity at low temperature asymptotically tends.

The Fig.1. shows the experimental data of $H_C(T^{1/2})$. The Monte Carlo calculations (not shown here) demonstrates the same tendency – two linear in ($T^{1/2}$) sections (dashed lines 1 and 2), at relatively high temperature, and asymptotical approaching to the single-particle anisotropy value in a low temperature area.

In both cases, the coercive force does not exceed the value of single-particle anisotropy, despite the fact, that stability boundary of the superferromagnetic state is exceeding this value. We assume, that at low temperatures, in Co/Al_2O_3 nanocomposite the magnetization reversal occurs thorough the formation of superdomains, and movement of superdomain boundaries, which are blocked only with single-particle anisotropy. And in the Monte Carlo calculations the low temperature limitation, of the coercive force by the single particle anisotropy field, is related with the loss of the stability of the magnetic moment of the whole ensemble, while at higher temperatures, in both cases, the coercivity is related with single-particle Neel relaxation and relaxation of superferromagnetic state.