Temperature damping of ESR and FMR for nanocomposites Co/Al_2O_3 in the superparamagnetic and ferromagnetic states

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Ferromagnetic nanocomposites (FMNC) Co_X/Al_2O_3 with the Co content within X = (16 ÷ 41) at.% were grown on the polycor substrates using the laboratory single-chamber electron-beam facility. The Co amount in FMNC determines the dimensions of Co nanoparticles (NPs). A transition from superparamagnetic state (SPS) to FM state due to magnetic dipole-dipole interaction between NPs (appearance of hysteresis loop) occurs at higher temperatures for larger dimensions of Co NPs.

For the first time the temperature damping of the electronic spin resonance (ESR) for 16 at.% in the SPS and FMR damping for 41 at.% Co in the ferromagnetic state was firstly observed. The studies were performed by Bruker spectrometer (9,4 GHz) in the temperature range T = (3÷270)K.

When the temperature lowers from 260 K FMR signal amplitude A for sample 41 at.% Co disappears at T< 60K. The observed magnetic resonance field H_R decreases by almost 50% (see Table). ESR signal disappears at T<20 K and H_R decreased by 10 % for 16 at.% Co.

T, K	H_R, kOe	A, arb.u.
261	5.63	16
231	5.56	15
202	5.41	14
161	4.89	8
125	3.81	6

We interpret this result in terms of the magnetic resonance condition in inhomogeneous media which is the following: $h\nu = \mu g(H_r + H_{in}), H_r + H_{in} = H_R$, where μ - Bohr magneton, H_r - resonance field, H_{in} - internal magnetic field. For 16 at.% Co we observe $H_R = H_r = 3.39$ KOe at g ≈ 2. For 41 at.% Co H_R is much larger (see Table). The existence of an internal magnetic field H_{in}, promotes temperature-dependent violation for resonant precession of the magnetic moments. The reason of this phenomenon can be the interaction of Co ferromagnetic core of NPs with its antiferromagnetic CoO shell. The Neel temperature (T_N) for bulk CoO is 291 K, but it strongly depends on NPs size. For example, in the case of the small width of CoO shell about 2 nm one observes T_N = 55K. It is supposed that a NPs dispersion by dimensions determines the smooth ESR damping. Therefore more lower damping temperature for the case of 16 at.% Co can be due to diminishing of T_N for CoO in the case of smaller Co NPs.

The presence of CoO in FMNC was evidenced by our researches: X-ray analysis; bend type temperature dependence of the thermoelectric power [1]. The existence of antiferomagnetic CoO shell also was confirmed by "magnetic exchange bias" of the hysteresis loop and the asymmetry of the angular dependence of H_R [2].

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[1] A.I. Dmitriev, G. V. Lashkarev, M. V. Radchenko. Phys. of Solid State, **55**, 687 (2013).

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