Manipulation of magnetic properties for $Co-Al_2O_3$ nanocomposites

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Electron beam evaporation of Co and Al_2O_3 from two crucibles was used for deposition of granular layers ($5 \div 7$ mkm) on polycor substrate. The Co amount in ferromagnetic nanocomposite (FMNC) determines the dimensions of Co nanoparticles (NPs) and the transition temperature (TT) from spin-glass state to superparamagnetic state (SPS). Thus TT is ~ 200 K at NPs dimensions $d \sim 10 \div 20$ nm, 50 K at $d \sim 3 \div 5$ nm and 12 K at $d < 3$ nm. Consequently a transition from FM to SPS state due to exchange interaction between FMNPs (appearance of hysteresis loop) occurs at lower temperatures for smaller dimensions of Co NPs.

Giant magnetothermoelectric power (TP) at low temperatures with a strong dependence on magnetic field was observed. It is due to a hopping spin-dependent transport of electrons between magnetic centers of electron localization containing Co atoms and through a tunnel-transparent alumina interspaces between FM nanoparticles under the influence of a temperature gradient.

The growing of eight sets of FMNC was carried out in magnetic field in parallel and perpendicular orientation to the sample plane (plane of the light magnetization). SEM images of these samples confirm the influence of magnetic field on the process of FMNC formation which is expressed in the preferable orientation of Co NPs long axis in the direction of magnetic field gradient. The latter is the reason for movement of Co atoms at forming Co NPs.

For the samples grown in magnetic field diminishing of electric percolation threshold (from 43 to 27 at.% Co) was observed which is due to lowering of a tunnel barrier between Co NPs. The maximum value of negative magnetoresistance ~ 4 % at 2,5 kOe was demonstrated for samples, grown in magnetic field which was perpendicular to the sample plane.

The temperatures of the transition into spin glass state (Ts) for samples formed in the magnetic field parallel ($Ts_{||}$) and perpendicular ($Ts^{\perp}$) to the sample plane are different: $Ts_{||} < 5$ K, $Ts^{\perp} \sim 20$ K. It is supposed to be obliged to increasing of magnetic field in a sample plane of light magnetization due to a disposition of long axis of Co NP in this plane.