Electronic transport and magnetic properties of Co/SiO_2 ferromagnetic nanocomposites

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Ferromagnetic nanocomposites (FMNC) are materials which consist of Co nanoparticles distributed in SiO_2 dielectric matrix. Their layers were grown on polycore substrates by electron beam evaporation technology. Co concentrations were 17, 31.7 and 65.4 at.%. Galvanomagnetic, electrical and thermoelectrical properties were studied in the temperature range 77-290 K and in magnetic fields $H \leq 5$ kOe. Magnetic measurements were carried out with the magnetic field applied in the plane of the sample layer. Temperature dependences of magnetization were measured in ZFC - FC regime under the *dc* magnetic field H = 50 Oe in the 5 – 300 K temperature range. The isothermal magnetization curves were collected in the magnetic field range ± 90 kOe at 5 and 300 K.

Scanning electron microscopy shows that the FMNC consist of dense packed Co nanoparticles with linear dimensions within the range 7-13 nm for 17 at.% Co sample. With increasing Co concentration nanoparticle dimensions become larger.

In Mott coordinates $\ln(\rho/\rho_{77}) \propto (1/T)^{1/4}$ the specific electrical resistance is linear in the temperature range 95-290 K and can be explained by hopping mechanism of electron transport between localized states. Earlier in FMNC Co/Al_2O_3 the giant positive thermoelectric power (TP) in magnetic field was discovered in conditions of hopping electron conductivity between nonmagnetic localization centers in the presence of magnetic centers which don't scatter electrons in magnetic field due to parallel displacement of spins and magnetic moments [1].

In Co/SiO_2 we observed the negative TP in magnetic field. This phenomenon can be explained by formation of nanosized ferromagnetic Co silicides and antiferromagnetic CoO during the deposition of nanocomposite Co/SiO_2 layer, what results in space fluctuations of Co nanoparticles magnetic moments leading to increasing electron scattering in magnetic field.

The thermal dependences of magnetization obtained for the sample with 31.7 at % Co shows the behavior typical to a superparamagnetic system. The maximum of $M_{ZFC}(T)$ curve corresponds to the thermal blocking of nanoparticle magnetic moments with the average blocking temperature $T_B \approx 48$ K. For sample with 65.4 at.% Co the superparamagnetic behavior was not detected up to 300 K. The magnetic behavior observed for 65.4 at.% Co sample can be related to the presence of large Co nanoparticles and significant inter-particle magnetic interactions. Both of these factors substantially modify the magnetic anisotropy energy barrier for reversal magnetization and change single particle to collective magnetic behavior of concentrated nanoparticle system what leads to increasing of a coercive force.

[1] G.V.Lashkarev, M.V.Radchenko et al., Phys. Stat. Sol. (b), **254**, 1700153 (2017).