Electrical and galvanomagnetic properties of ferromagnetic composites Co/Al_2O_3 in magnetic field

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Among nanocrystalline magnetic materials the separate place is occupied by ferromagnetic nanocomposites (FMNC), which consist of magnetic nanoparticles (NP′s) distributed in a diamagnetic matrix. Scientific and applied interest in these materials is caused by the possibility of controlling their magnetic and electrical properties by changing the size, shape and concentration of ferromagnetic nanoparticles.

Co/Al_2O_3 FMNC layers were grown by two-crucible electron beam evaporation technique with Co and Al_2O_3 vapors condensation in vacuum on polycore substrates placed in a magnetic field of different directions [1]. The growth of FMNC layers in magnetic field H leads to the their characteristic microstructure with Co NP′s oriented along magnetic field with their longer axes forming fibers observed by electronic microscopy techniques. This magnetoactive technology of ferromagnetic nanocomposites opens new possibilities for the control of materials properties.

In this work, we show how anisotropic magnetic microstructure influences electrical and galvanomagnetic properties of FMNC. At Co concentration higher than percolation threshold electron transport between magnetic fibers occurs by hopping mechanism, instead of metallic conductivity observed in FMNC without fiber microstructure.

For low Co content their electric resistivity follows the $\rho \sim \exp(1/T)$ dependence whereas for high Co content (> 30 at.%) electrical resistivity is described by the law $\rho \sim \exp(T^{-1/4})$. At low Co concentration (and small number of ferromagnetic NP′s) electronic transport through localization centers in Al_2O_3 matrix with a thermal activation character is predominating one. In contrast, at high concentration of Co NP′s electronic transport proceeds via variable range hopping mechanism.

We observed the regularity of higher longitudinal magnetoresistance (MR) values in the case of FMNC′s grown in perpendicular magnetic field and vice versa for transverse MR. These peculiarities are related to such arrangement of electron trajectories in magnetic field at which they cross predominantly the streaks between fibers of Co NP′s.

Thus growth of FMNC in magnetic field modifies essentially their properties.

[1] M.V.Radchenko, G.V.Lashkarev, M. E. Bugaiova, S.V.Trushkin, W.Knoff,T. Story, L.I.Petrosian, Nanostructured material science **3-4**, 42 (2014)