New features of giant thermoelectric power in magnetic field for Co/Al_2O_3 nanocomposites below the percolation threshold

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The thermoelectric power (α), electrical resistivity and magnetic properties of ferromagnetic nanocomposites (FMNC) Co/Al_2O_3 were investigated in the concentration region 23,7-25,5 at.% of Co in the temperature range (4,2-300) K and in magnetic fields (H) up to 5 kOe.

Earlier in samples of Co/Al_2O_3 below percolation threshold of Co concentrations, the giant thermoelectric power in a magnetic field (GMTEP) in the temperature range above 85 K was found, exceeding the thermoelectric power at the same temperature but without a magnetic field in 3-5 times [1]. This phenomenon was explained by the hopping mechanism of electron transfer through magnetic centers containing Co in a dielectric matrix in the conditions of a temperature gradient. In such case the influence of the magnetic field, in our opinion, causes a decrease in the electrons scattering with spin rotation due to the cooperative orientation of magnetic moments of electrons and magnetic localization centers.

We observed maximum α(T) in the minimal temperature (the growth of α about ~ 160 times) when sample was cooled without a magnetic field H. However, when it was cooled in the switched-on magnetic field, GMTEP did not appear. An explanation of the giant α in the last case can be a transition from the superparamagnetic state of FMNC to ferromagnetic one due to the orientation of magnetic moments for Co nanoparticles and centers of localization by an appearing internal magnetic field. As a result, the external magnetic field changes insufficiently. Thus there must be a correlation of the temperature for the maximum α(T) with the transition to the spin glass state.

Thereby, GMTEP is a multifunctional effect that depends on temperature, magnetic field, composition (and hence on the concentration of magnetic centers) and the prehistory of various factors action on the sample. Thus, discovered effect is the complicated one and needs additional experimental studies and calculations.

The influence of thermal annealing on the GMTEP phenomenon and the electrical properties of FMNC was investigated.

[1] G.V. Lashkarev, M.V. Radchenko at. all, Spin-dependent phenomena in Co/Al_2O_3 ferromagnetic nanocomposites// 42nd "Jaszowiec" International School & Conference on the Physics of Semiconductors 2013, June 22-27.