MAGNETOTRANSPORT PROPERTIES OF CARBON NANOTUBES DECORATED WITH MAGNETIC ALLOYS

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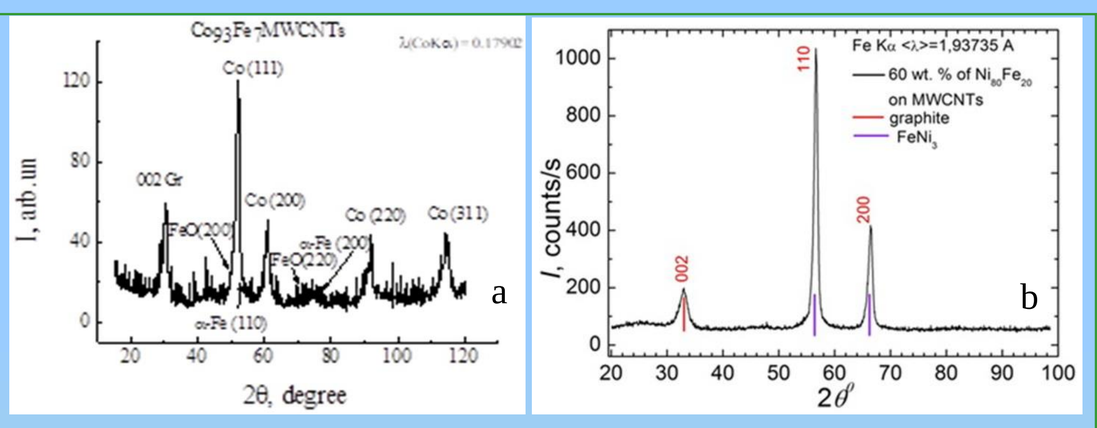
The purpose: to identify the peculiarities of the angular and temperature dependences of the magnetoresistance of multi-walled carbon nanotubes decorated with magnetic alloys

Obtaining of MWCNTs

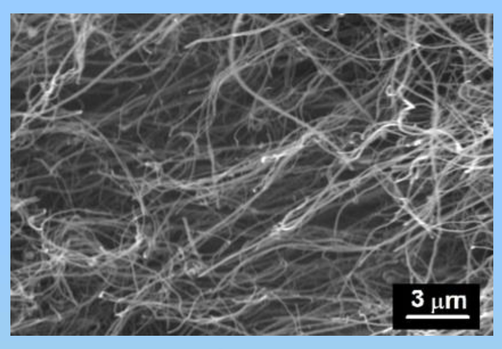
The source MWCNTs with a purity of ~90% were obtained by catalytic chemical deposition from the gas phase and cleaned of catalysts with acid solutions.

Decoration of MWCNTs with magnetic particles

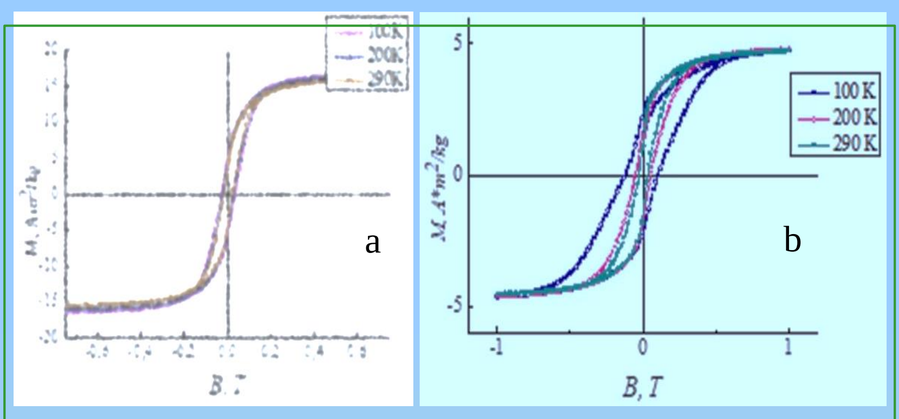
To decorate the surface of MWCNTs with $Co_{93}Fe_{07}$, $Ni_{80}Fe_{20}$, and $Ni_{20}Co_{80}$ magnetic alloys' nanoparticles, the initial nanotubes were impregnated with aqueous solutions of corresponding salts, followed by the reduction of metals in a flow of helium and hydrogen gaseous mixture.



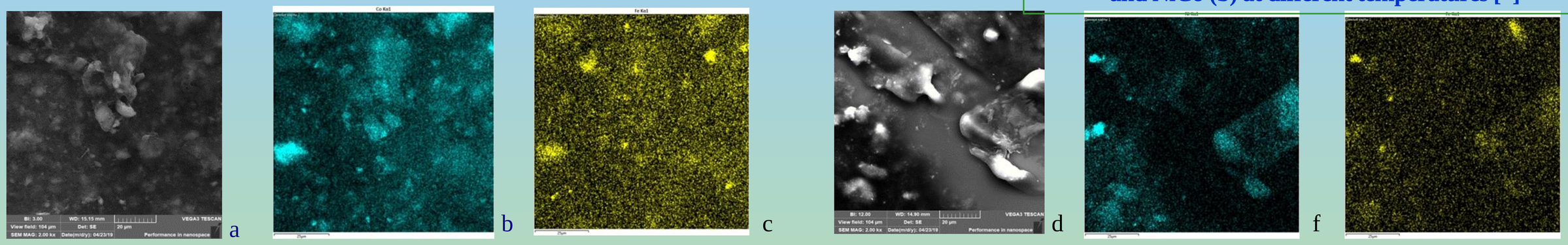
Fragments of *X*-Ray diffraction patterns for MWCNTs decorated with $Co_{93}Fe_{07}$ (a) and $Ni_{80}Fe_{20}$ (b) nanoparticles.



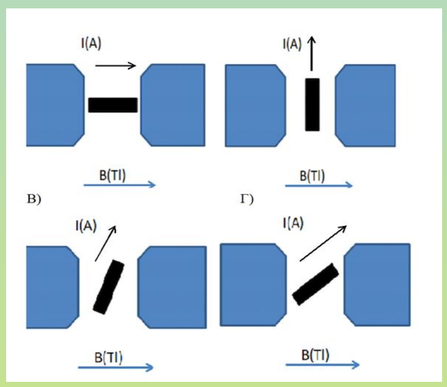
SEM-image of source MWCNTs



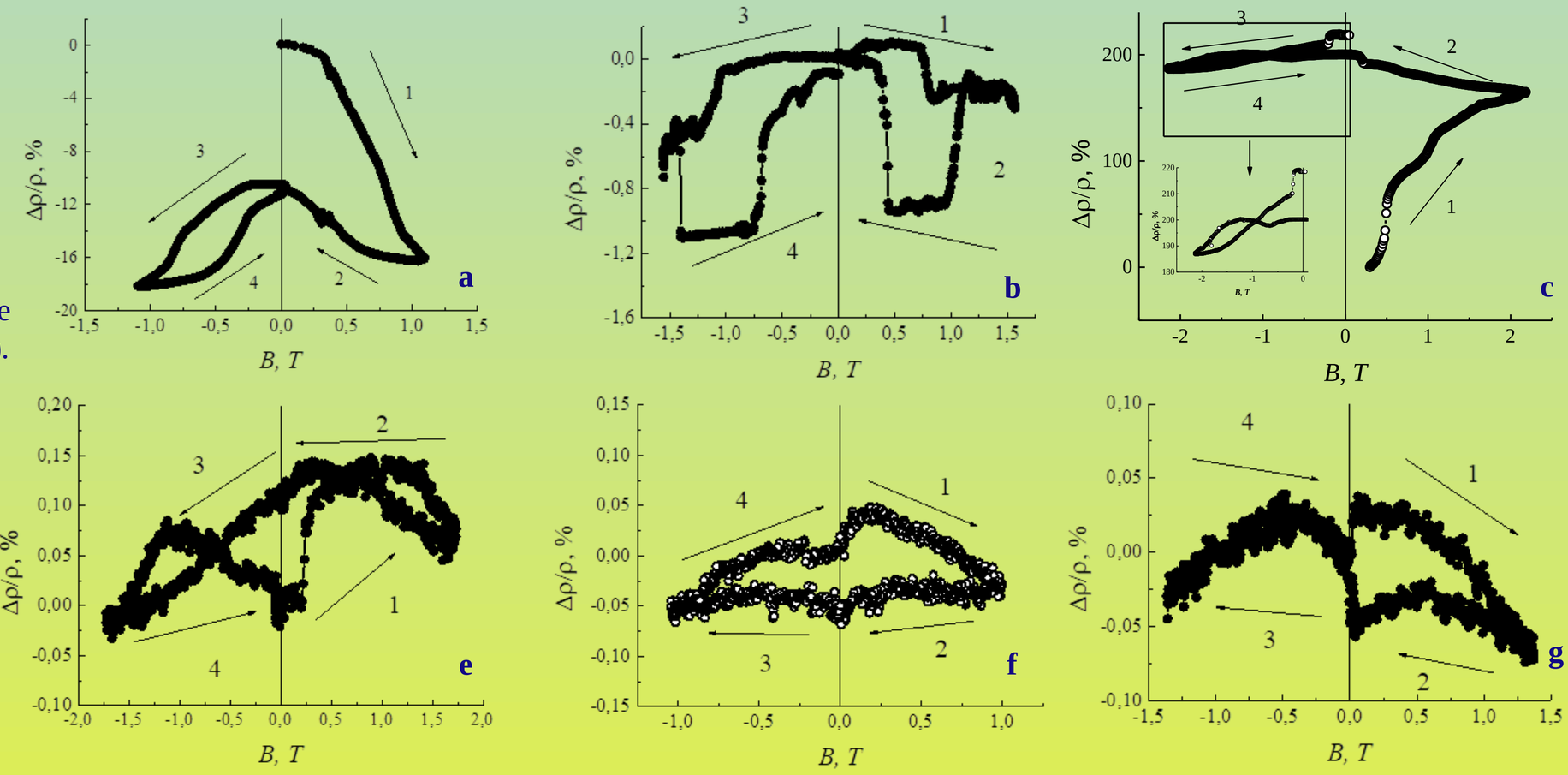
Hysteresis loops for MWCNTs decorated with NiFe (a) and NiCo (b) at different temperatures [*]



SEM surface images of MWCNTs decorated with $Co_{93}Fe_{07}$ (a) and $Ni_{80}Fe_{20}$ (d) nanoparticles, and corresponding EDS pictures for Co (b) and Fe (c), and Ni (f) and Fe (g) [*]



Orientation of the measured sample relative to the magnetic field ($\alpha = 0^0, 30^0, 60^0, 90^0$).



$\Delta\rho/\rho_0$ dependences for bulk samples of MWCNTs decorated with $Ni_{80}Fe_{20}$ (a-c), $Co_{93}Fe_{07}$ (d-e) and $Ni_{20}Co_{80}$ (f-g). $\alpha = 0^0$ (a, d, f), $\alpha = 30^0$ (b, e, g) and $\alpha = 90^0$ (c).

Conclusions

1. NiFe nanoparticles on the surface of MWCNTs are in a ferromagnetic state. NiFe is a soft ferromagnet, for which the width of the hysteresis loop area is small, and the coercive force does not exceed $H_c = 0.035$ T at room temperature and $H_c = 0.065$ T at $T = 100$ K.
2. The hysteresis loops for NiCo- and FeCo-decorated MWCNTs are typical of the magnetic phase in a superparamagnetic state. They are characterized by significantly larger coercive force values and magnetization saturation field values.
3. The results of studies of structural characteristics and magnetic properties of MWCNTs decorated with NiFe magnetic alloy suggest that the primary mechanism of magnetoresistance for MWCNTs decorated with NiFe is a giant magnetoresistive effect for granular systems.
4. For MWCNTs decorated with NiCo- and CoFe-nanoparticles, which are in a superparamagnetic state on the MWCNTs surface, the contribution of a giant magnetoresistive effect to the total magnetoresistance is significantly smaller.
5. The magnetoresistive effect for all samples of MWCNTs decorated by nanoparticles of magnetic alloys has an anisotropic character.

*Matzui L.Yu., Vovchenko V.V., Syvolozhskyi O.A., Yakovenko O.S., Borovoy M.O., Gomon O.O., Dyachenko A.G., Ishchenko O.V., Vakalyuk A.V., Bodnaruk A.V., Kalita V.M. Mol. Cryst. Liq. Cryst. **752**(1), 77 (2023).