ANGULAR DEPENDENCE OF MAGNETORESISTANCE OF FILLED WITH IRON CARBON NANOTUBES

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Aim — **Investigation of magnetoresistance in MWCNTs, which include internal cavity of the particle magnetic phases, depending on temperature, the relative orientation of the magnetic field and current and ordering samples**

The structure — X-R diffraction, Electron microscopy

Magnetoresistance — Standard technique; Temperature: (77-293)K

Two specimens of MWCNT's

Specimen #1

MWCNT's are produced by chemical vapour deposition in a tube furnace using benzene (as the source of carbon) and ferrocene (as the source of iron). The external diameter of the tubes is ranged from 65 to 70 nm. The inner diameter of the tube's equals ~ 6-10 nm.
MWCNT contains clusters of iron (or its compounds) with average diameter (10-15) nm and length (120-140) nm

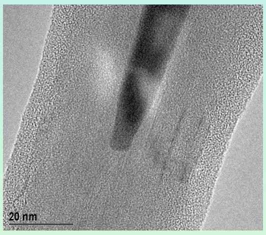

Figure 1. TEM image of MWCNT's specimen #1

Specimen #2

An array of parallel oriented MWCNTs, in the inner cavity of which are particles of iron or its compounds with a diameter of ~10 nm

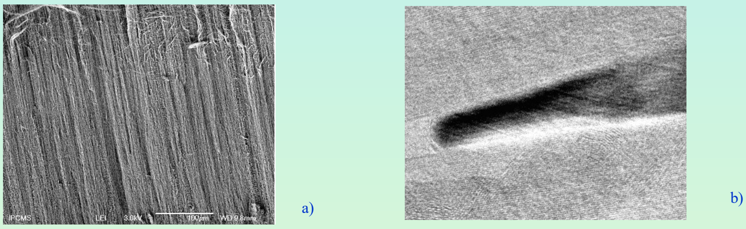

Figure 2. TEM images of MWCNT's specimen #2: (a) and (b) are different magnification

Magnetoresistance is defined as: $\frac{\Delta R}{R} = \frac{R_B - R_0}{R_0}$, where R_B is specimen's resistance in magnetic field and R_0 – without magnetic field

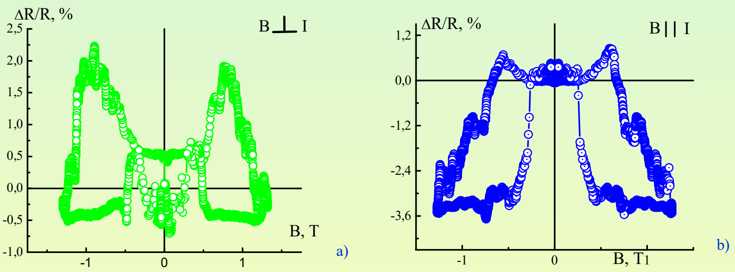

Figure 3. ΔR/R(B) dependence for MWCNT's specimen #1: (a) B ⊥ I and (b) B||I; T=293 K.

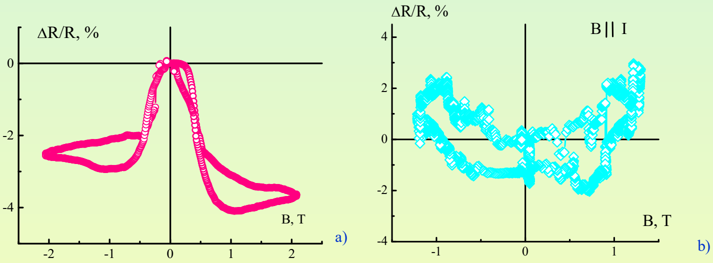

Figure 4. ΔR/R(B) dependence for MWCNT's specimen #1: (a) B ⊥ I , T=293K and (b) B||I; T=77 K

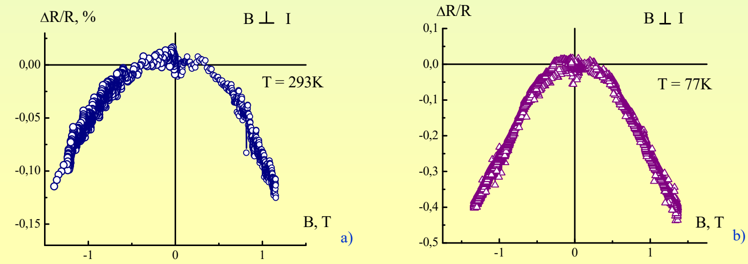

Figure 6. ΔR/R(B) dependence for MWCNT's specimen #2: (a) T=293 K and (b) T=77 K; B⊥I.

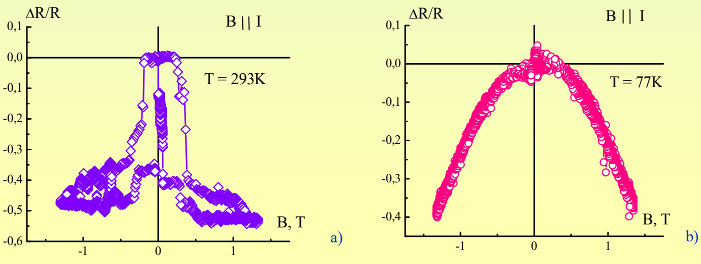

Figure 7. ΔR/R(B) dependence for MWCNT's specimen #2: (a) T=293 K and (b) T=77 K; B||I.

Two mechanisms of magnetoresistance in layered or clustered systems with alternating magnetic and nonmagnetic layers or magnetic clusters are in a nonmagnetic matrix:

1. **Giant magnetoresistance mechanism (GM). A characteristic feature of GM is a hysteresis phenomenon in the case of magnetoresistance dependence on magnetic field.**
2. **Anisotropic magnetoresistance (AM). A characteristic feature of AM is a dependent of sign magnetoresistance on the relative orientation of the magnetic field M and current I:** $R(\theta_{M,I}) = R_0 + R_\Delta \cdot \cos^2(\theta_{M,I})$, $R_\Delta \equiv R_\parallel - R_\perp$.
3. Magnetoresistance of MWCNT's filled with iron and its compounds strongly depends on the structure of CNT and their mutual orientation, and also structural and morphological state of the magnetic phase. For partially oriented Fe-MWCNT's the magnetoresistance is determined by a combination of two mechanisms, namely, GM and AM. For array-oriented Fe-MWCNT's in mutually perpendicular orientation of the magnetic field and current a principal mechanism is the localization magnetoresistance mechanism, and in mutual parallel orientation of the magnetic field and current – a GM effect.