# FUNCTIONAL NANOCOMPOSITES BASED ON SINGLE-WALLED CARBON NANOTUBES – SYNTHESIS AND INVESTIGATION

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Single-walled carbon nanotubes (SWNTs) first produced in 1991 by arc-discharge vaporation method nowadays draw close attention of scientific community worldwide due to their unique electronic and structural properties accompanied by extraordinary mechanical behavior depending on the diameter and conformation of tubes. Well-defined atomic structure, ultra small diameter (from 0.4 nm) and the highest length to diameter ratio makes SWNTs extremely attractive as the perfect templates for the formation of 1D nanocrystals inside the channels. Chemical design of SWNTs via filling of tubes with favourable conductive, optical or magnetic materials impulses the development of novel class of nanotube architectures and nanoscale materials. For instance intercalation of the electron donors (with Fermi level located in the conductance band) to the metallic tubes will lead to increase of electron density on carbon walls resulting in better conductance through the composite wire while intercalation of electron acceptors (with Fermi level below one of SWNT) may cause the system to demonstrate semiconductor behavior. This concept allows to tune electronic structure of SWNTs by intercalation of metallic, semiconductor or dielectric materials enabling their great potential applications as active elements of electronic devices and circuits.

The present study is focused on the controllable growth of 1D conductive nanocrystals in channels of carbon nanotubes with inner diameter 1-1.4 nm and investigation of their effect on electronic properties of nanocomposites. SWNTs were obtained by catalytical arc-discharge method with following purification and pre-opening by treatment at 500ºC in dry air for 0,5 hour. The nanocomposites were prepared using capillary technique via impregnation of oxidized SWNTs in static vacuum of 0.01 mbar by molten salts CuI, CuCl or AgI at temperatures 100ºC above the melting point of the correspondent salt.

SWNTs and filled carbon nanotubes were characterized by high resolution TEM, Raman and impedance spectroscopy, EDX and surface analyses. According to capillary adsorption studies the specific BJH surface area of pre-opened SWNTs decreases after the impregnation procedure (for example, with CuI) from 1073 $m^2/g$ down to 43 $m^2/g$ nearly with unchanged pore size distribution pointing out the incorporation of guest material into inner channels of nanotubes. EDX microanalysis and HRTEM imaging of all obtained nanocomposites proved the successful filling of SWNTs channels with fine nanocrystals of chosen materials (up to ~73 wt.%). Raman spectroscopy data of CuI, CuCl and AgI@SWNTs demonstrated the changing of electronic properties of composites resulting in the shift of RBM- и G-peaks as compare to row nanotubes. The Raman spectra of CuI@SWNTs, for instance, showed considerable broadening of G-modes and shifts to lower frequencies, both with the disappearing of $G^-$-line of metallic tubes which can be ascribed to the shift of electronic band structure of filled SWNTs and transition of the metallic tubes to the semiconductive state.

Besides, the additional resistance measurements of single SWNTs bundle with diameter <100 nm and length of ~20 μm were performed indicating the resistance value of ~1 MΩ, which corresponds to the metallic conductivity. The investigation of I-V curves and electrical impedance of individual SWNTs shelled with amorphous carbon showed the metallic behavior with the resistivity of inner channel equal $0{,}7\cdot10^{-5}$ Om·cm.

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