

New Materials Based on Filled Single-Wall Carbon Nanotubes

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Films of filled single-walled carbon nanotubes represent a new nanocarbon material with properties variable by choosing the type of host nanotubes and the type of filler. While the nanotube outer structure remains unchanged under a non-destructive gas-phase filling, their inner space serves as a nanoreactor for formation of new structures. The atomic chains and one-dimensional crystals formed inside nanotubes demonstrate dimensional effects, change of the crystal structure (comparing with the bulk crystals), effects of charge transfer between nanotube and filler. Simultaneously the properties of the whole macroscopic film are changed. This allows using them for different applications.

In this paper, 3 types of filling will be considered: with fullerene molecules (C_{60})[1], with coronene molecules ($C_{24}H_{12}$) [2] and with the electron acceptor molecules (iodine and CuCl) [3,4]. In the first case the transformation of the fullerene chains into the inner tube were monitored via measuring the one- and two-phonon Raman scattering [1]. The coronenes also merge inside nanotube and form a graphene nanoribbon. The width-dependent photoluminescence of nanoribbons have been registered for the first time [2]. In case of filling with acceptor molecules the charge transfer from nanotube to the filler takes place. This leads to p-type doping of nanotubes. The macroscopic films demonstrate a decrease of electrical resistance of one order of magnitude and an increase of optical transparency [3,4]. Such material is prospective for formation of conductive transparent electrodes.

The changes in the properties of the films as a result of the filling of nanotubes will be analyzed and the prospects for the use of such films will be outlined.

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1. R. Pfeiffer, H. Kuzmany, F. Simon, S.N. Bokova, E. Obraztsova "Resonance Raman scattering from phonon overtones in double-wall carbon nanotubes", *Phys. Rev. B*, 71(2005) 155409.
2. A.I. Chernov, P.V. Fedotov, A.V. Talyzin, I.V. Anoshkin, A.G. Nasibulin, E.I. Kauppinen, E.D. Obraztsova "Optical Properties of Graphene Nanoribbons Encapsulated in Single-Walled Carbon Nanotubes", *ACS Nano* 7 (2013) 6346.
3. A.A. Tonkikh, V.I. Tsebro, E.A. Obraztsova, K. Suenaga, H. Kataura, A.G. Nasibulin, E.I. Kauppinen, E.D. Obraztsova, "Metallization of single-wall carbon nanotube thin films induced by gas phase iodination", *Carbon* 94 (2015) 768.
4. V.I. Tsebro, A.A. Tonkikh, D.V. Rybkovskiy, E.A. Obraztsova, E.I. Kauppinen, E.D. Obraztsova "Phonon contribution to electrical resistance of acceptor-doped single-wall carbon nanotubes assembled into transparent films", *Phys. Rev. B* 94 (2016) 245438.

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