# Morphology and transport properties of B, N and BN-doped carbon materials synthesized using arc discharge procedure

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Arc discharge is a capable route for mass production of metal-free multi-walled carbon nanotubes (MWCNTs). The doping of carbon nanostructures with heteroatoms, such as boron or nitrogen, is one of the effective ways to change their properties as required by the application. Taking into account diversity of morphologies of carbon nanostructures produced by arc discharge method, finding how transport properties depend on doping and the structure of the material can make transport measurement a useful characterization tool. Here, we report the effect of introduction of nitrogen and boron species in an electric arc on composition of cathode deposits and analyze their transport properties.

The pure carbon and doped carbon materials were synthesized in an electric arc using apparatus described elsewhere [1]. The doping of carbon material with nitrogen and/or boron was achieved by a vaporization of graphitic electrode in nitrogen atmosphere and boron-filled electrode in nitrogen or helium atmosphere. The samples were examined by transmission electron microscopy, Raman spectroscopy, and Near-edge X-ray absorption fine structure (NEXAFS) spectroscopy and X-ray photoelectron spectroscopy (XPS, spectra were measured at the BESSY II using radiation from the Russian-German beamline). Temperature dependence of the samples' conductivity was measured at zero magnetic field from the liquid helium to room temperature. The Hall coefficient and magnetoresistance (MR) were determined for the same specimen in a helium atmosphere.

It was noticed that the addition of nitrogen and boron in arc discharge process changes the composition, atomic ordering, charge carrier density, and in effect – transport properties of arc discharge product. A comprehensive characterization confirms a successful nitrogen and boron substitution in graphite lattice, corresponding to *n*- and *p*-type conducting N-doped composite and B- and BN-doped composites, respectively. Even at low impurity content, incorporation of boron in carbon network is accompanied with formation of structural defects that endows the arc discharge composite with transport properties of disordered electronic system governed by the weak localization and diffusive scattering effects. In the presence of nitrogen, we obtained the well-graphitized arc discharge product, which, among other nanocarbons, includes submicron-sized graphite plates. N-doped composite exhibits low-field (<3000 G) negative MR which arises from disordered nature of nano-sized structures crossovers to positive MR at higher field. We attribute this effect to compensation from ordinary positive MR in big graphite plates.

This work was done with the support of Russian Foundation for Basic Research (Project 17-52-04077). O.V. Sedelnikova thanks the Scholarship of the President of the Russian Federation (SP-3530.2016.1).

[1] A. V. Okotrub, Yu. V. Shevtsov, L. I. Nasonova, D. E. Sinyakov, O. A. Novoseltsev, S. V. Trubin, V. S. Kravchenko, L. N. Mazalov.. Pribory i Tekhnika Experimta **1**, 193 (1995).