Application of angle-resolved X-ray spectroscopy for characterisation of oriented CNT films

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Angle resolved X-ray emission and absorption spectroscopy is typically used for investigation of anisotropy of chemical bonds in graphite-like materials [1, 2]. X-ray emission and absorption spectra of graphite materials, obtained under conditions of different incident angles and different angles of emission radiation yield, show dependence of intensities of X-ray spectra features, which can be correspond to the electron transitions with π- and σ- orbitals.

Films of oriented carbon nanotubes (CNT) with different texture of samples were synthesized by CVD-method with using of asetonitrile and toluene as a source of carbon. Films of oriented CNT, synthesized by this method, have the significant amount of defects, which lead to imperfection of whole material. Investigation of structure of oriented CNT films were carried out by method of angle resolved X-ray spectroscopy. The results of scientific research shows that relative intensities of X-ray spectra feature contain information about difference of CNT structure from the ideal cylindrical. Modeling of intensities of X-ray spectra and comparison of experimental results with other experimental methods allows obtaining information about texture and defectiveness of CNT films, as well as specifying the model of formation of CNT films during CVD-synthesize.

Investigation of angle resolved X-ray absorption spectra near NK-edge of oriented CNT films, doped by nitrogen atoms, allows to determine orientation of N_2 molecules, incapsulated in the space, between nanotube walls.

[1] Y.H. Tang, T.K. Sham, Y.F. Hu, C.S. Lee, S.T. Lee, *Chem. Phys. Lett.* **366**, 636 (2002).
[2] T. Hemraj-Benny, S. Banerjee, S. Sambasivan, D.A. Fischer, G. Eres, A.A. Puretzky, D.B. Geohegan, D.H. Lowndes, J.A. Misewich, S.S. Wong, *Phys. Chem. Chem. Phys*. **8**, 5038 (2006).