Interplay between intrinsic and contact phenomena in carbon nanotube devices: from exponential magnetoresistance to chemical sensing

Fedorov G.*[1], Yang Y.[2], Barabra P.[2], Jiménez D.[3], Smirnov D.[4], Roche S.[5]

[1]NRC "Kurchatov Institute", 123182, Moscow, Russia
[2]Georgetown University, 20057, Washington, DC, USA
[3]Universitat Autònoma de Barcelona, 08193 Barcelona, Spain
[4]National High Magnetic Field Laboratory, Tallahassee, 32310, USA
[5]CIN2, ICN, CSIC, Barcelona, E-08193 Bellaterra, Spain
**e-mail: gefedorov@mail.ru*

Back in 1993 Ajiki and Ando predicted linear dependence of the band gap of a carbon nanotubes (CNT) on a magnetic field parallel to the CNT axes [1]. This effect arises from modulation of the Aharonov-Bohm phase of the electronic wave functions and peculiar topology of the graphene's Fermi surface. In our previous work [2] we employed this effect to study relationship between the band structure of a CNT and transport properties of a CNT-based device. Our experimental results were successfully interpreted within a compact phenomenological model describing charge transport in CNT-based field-effect transistors (CNFETs) [3]. Here we present this model and its implementation to analysis of chemical sensitivity of CNT-based FET devices.

We have studied transport characteristics of CNFETs of different configuration as a function of the concentration of ammonia and nitrogen dioxide in the surrounding atmosphere. Interpretation of experimental results is based on the assumption that adsorption of gas molecules on the CNT surface changes parameters of its band profile, i.e. the Schottky barrier height and the CNT doping level. It is shown that within this approach, we get at a good qualitative description of our experimental data, as well as previously published data obtained by other research groups. We conclude that the presented model for Schottky-barrier nanotube-based transistors can be successfully implemented to simulate the response of CNT-based chemical sensors.

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