Electronic transport and flicker noise in graphene structures

Submitted by Alexey A. Kaverzin to the University of Exeter as a thesis for the degree of Doctor of Philosophy in Physics
November, 2011

I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

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November, 2011

Abstract

In this thesis the properties of graphene are studied via the various aspects of the quantum transport: doping of the graphene surface with organic molecules, flicker noise and transport in the quantum Hall regime.

First, it was shown that certain molecules (toluene, aniline and water), which possess such common properties as non zero dipole moment and ability to undergo the electrochemical reaction, have a peculiar doping effect on graphene. The effect of toluene doping was studied in detail and is explained by the electrochemical reaction, which takes place in the vicinity of the graphene and results in a gate voltage dependent doping.

Second, the flicker noise in graphene and its relation to the scattering mechanisms were studied. The flicker noise as a function of the carrier concentration was demonstrated to be sensitive to the scattering potential determining the resistance of the graphene. Therefore, as it was suggested, the flicker noise can be used as a tool for determining the dominant scattering mechanism in graphene, although it was found that the resistance and noise can originate from different scattering potentials.

Also, the flicker noise spectrum was shown to decompose into individual lorentzians at low temperatures (below $\sim 25\,\mathrm{K}$), where the fluctuations of the resistance is supposedly coming from the random jumps of electrons between the conductive channel in the graphene flake and the nearby impurity states.

Third, the transport properties of the bilayer/trilayer graphene structure were studied at different temperatures and different magnetic fields including the quantum Hall regime. Bilayer and trilayer parts of the sample revealed the signatures of the quantum Hall effect predicted theoretically. The transport through the interface between bilayer and trilayer parts was also investigated. Signatures of the interface resistance were seen, although the observed behaviour is not explained. Under high magnetic fields the properties of the interface longitudinal resistance were described qualitatively by the classic transport equations.

Acknowledgements

I would like to show my deepest gratitude to the people whose persistent help and guidance were invaluable during the years of my studies in Exeter University.

I am very grateful to my former supervisor Prof. Alex Savchenko, who supported me a lot, not only in terms of my studies but also in terms of social life, especially during my first year of PhD. Prof. Savchenko continuously and convincingly conveyed to everyone, and to me in particular, his enthusiasm to the science.

A big thank you to my current supervisor Dr. David Horsell, with whom I have had very productive discussions, which summarised all the results I had and led to the publications. I would like to thank Dr. Andrey Shitov, who has willingly answered hundreds of my questions.

I wish to thank former students of our lab: Roman Gorbachev, Alexander Mayorov and Feodor Tikhonenko, who were my first teachers in all the measurement and fabrication techniques, and became the first friends I found here in Exeter. I owe a thank you to Adam Price for his continuous and detailed help with all the equipment in our lab. A big thank you to my colleagues Peter Hale, Freddie Withers, Aleksey Kozikov and Samuel Hornett, who were always there for advice and help of any sort. Thanks also due to the team of English native speakers of our lab, who were the first readers of all my papers, presentations and this thesis.

I would like to express my gratitude to the team of our technicians. David Manning, Adam Woodgate and David Gregory have kindly supplied our lab with the liquid helium. Paul Wilkins has helped me with many bits of the experimental set ups.

I would like to express my appreciation to the University of Exeter as this work would not have been possible without its financial assistance.

I am very thankful to my friends Sergey Alyamkin and Alexey Galda who believed in me since we were at school. A special thank you to my housemates and friends Ivan Khrapach, Timofiy Khodkov and Alexander Markevich for the great welcoming atmosphere in our house.

Of course, I cannot forget to thank my parents and my sisters for their unconditional love and support through all the years of my study.

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