Fabrication and transport properties of graphene-based nanostructures

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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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Abstract

In this work fabrication and studies of transistor structures based on an atomic sheet of graphite, graphene, are described. Since graphene technology is in its early stages, the development and optimisation of the fabrication process are very important. In this work the impact of various fabrication conditions on the quality of graphene devices is investigated, in particular the effects on the carrier mobility of the details of the mechanical exfoliation procedure, such as environmental conditions and humidity, source of graphite and wafer cleaning procedure. In addition, a comparison is made between the conventional e-beam lithorgaphy and lithography-free fabrication of samples. It was also demonstrated that water and other environmental species play an important role in graphene-to-substrate adhesion and can also contribute to the carrier scattering in graphene.

A technique for creating suspended metal gates was developed for the fabrication of graphene p-n-p structures, and charge transport has been studied in such top-gated graphene devices. Depending on the relation between the carrier mean free path and the length of the top-gate we have realized three distinct transport regimes through the p-n-p structure: a) diffusive across the structure; b) ballistic in the regions of p-n junctions but diffusive in the n-region; c) ballistic across the whole p-n-p structure. The second regime has revealed the chiral nature of carriers in graphene. This was demonstrated by comparing the experimental resistance of a single p-n junction with results of electrostatic modeling in the diffusive model. In the third regime we have observed oscillations of the device resistance as a function of carrier concentration in the n-region, which are also dependent on magnetic field. These oscillations have been demonstrated to be a direct consequence of a Fabri-Perot-like interference effect in the graphene p-n-p structures.

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