Field Effect, Stain and Doping in Graphene Antidot Lattice

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Graphene has been predicted to become widely integrated into future electronics, including high-speed transistor-based devices due to the reports of extreme mobilities [1]. While the lack of a bandgap prevents the necessary on/off ratios for such applications [2], several strategies have proven successful in inducing a transport gap. Among these, an antidot lattice allows not only introduction of a controllable bandgap, it also offers the intriguing possibility to guide electrons in a manner analogous to light in photonic bandgap structures [3]. Nanopatterning invariably introduces additional scattering and subsequent decreases in carrier mobility. It has, however, been predicted that just a fewer number of antidot rows can lead to a bandgap similar to that of a semi-infinite array, while maintaining an acceptable carrier mobility [4]. This study presents preliminary measurements on such devices.

Single-layer graphene produced via the exfoliation method was patterned using electron-beam lithography and reactive ion etching, into multiple contact Hall bars, equipped with several antidot lattices. Each Hall-bar contained four sections: a pristine section as well as three patterned sections with either: one row of holes, five rows of holes or array of 48 rows of holes. This device enabled the simultaneous comparison of pristine graphene to graphene with a well-defined array of holes on the same graphene flake.

The devices were fabricated on highly-doped silicon with a 300 nm silicon dioxide layer, which allowed back-gated measurements to be carried out. The electron and hole field-effect carrier mobilities as well as the gate bias required to observe a charge-neutrality point (CNP) were determined as a function of temperature (-195C to 150C). The temperature dependence of the antidots sections can be described as a combination of transport gap and variable range hoping, The prediction that a few rows of antidot leads to a minimal reduction of carrier mobility was confirmed. The interplay between nanopatterning, gate hysteresis and charge neutrality point offset was also studied.

In order to determine if the fabrication of Hall bars using electron-beam lithography has any effect on the strain and doping levels, high-resolution micro-Raman maps were taking at several stages during the fabrication process. Using results from the literature [5] the changes in strain and doping can be tracked. Micro-Raman maps of several thousand points were taking directly after exfoliation, after cleaning, after deposition of metal contacts (defined using EBL), and finally after definition of Hall-bar structures.

References

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[5] Larsen et. al. MNE2013 Proceedings, **In Press**

Figures

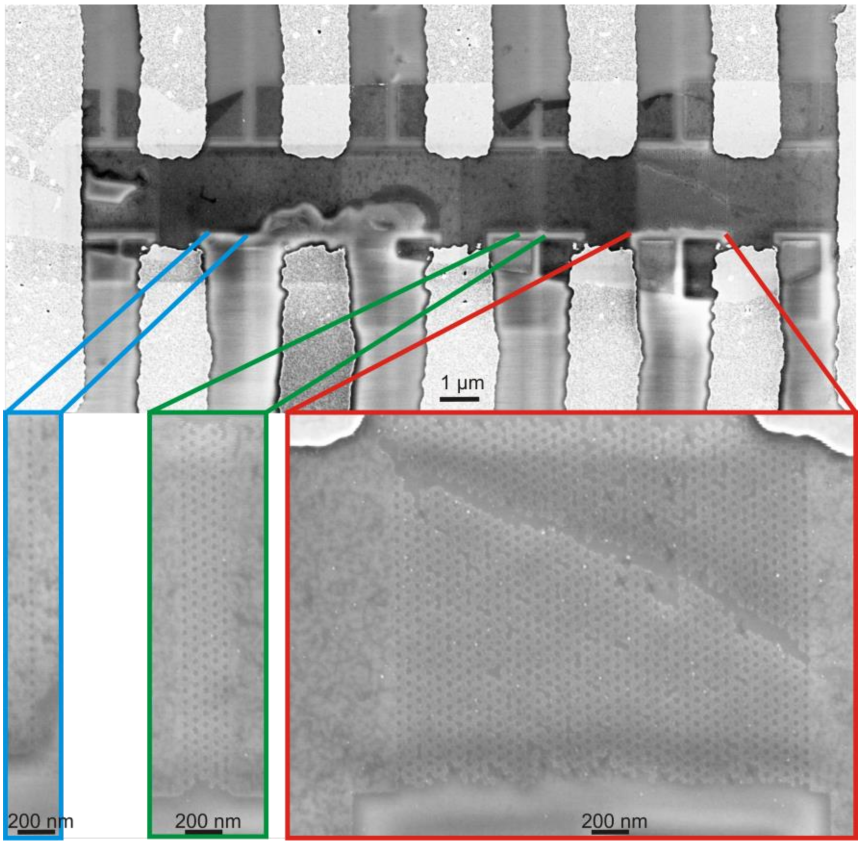

Figure 1: Scanning Electron Microscope image of a multi-contact Hall-bar with antidots defined via electron beam lithography with close-ups showing sections with an array of holes, 5 rows of holes and 1 row of holes. The holes have a diameter of 35 nm with a pitch of 55 nm.

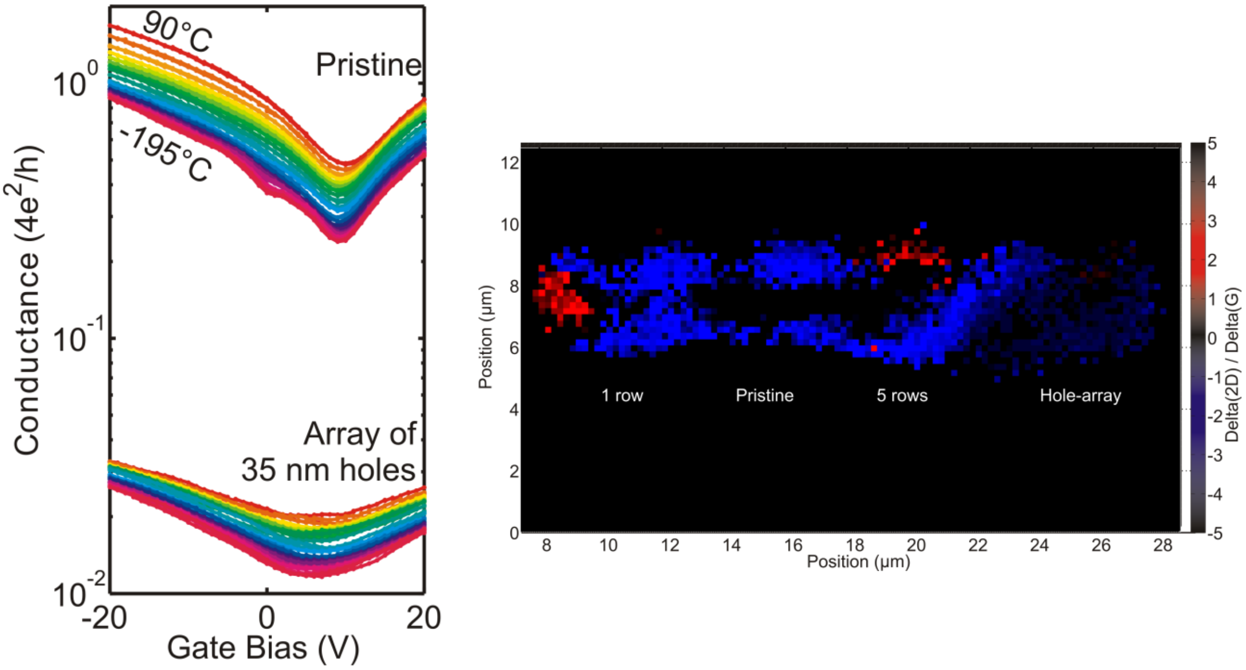

Figure 2: Left: Temperature Dependence data comparing the antidot array and the pristine sections of the device shown in Figure 1. Right: Raman map with extracted strain of device shown in Figure 1. The coloured regions indicate regions of high strain, and the black regions indicate low to zero strain.