Electronic scattering and nanoelectromechanical manipulation of graphene

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Using scanning tunneling microscopy (STM) and spectroscopy (STS), we perform an atomically resolved investigation of the electronic scattering behavior at impurities and a monolayer / bilayer step edge in graphene on SiO_2. Measurements at different tip-sample distances reveal a reversible transition between hexagonal and trigonal symmetry of the atomic corrugation interpreted as a tip-induced buckling, associated with different displacements of the flake.

STM allows a direct observation of microscopic scattering, which could possibly affect the electrical properties of this system. Our measurements reveal intense interference patterns with a wavelength of 0.37 nm. This $\sqrt{3}$x$\sqrt{3}$R30° superstructure is only observed in the vicinity of strong scatterers, such as edges or adsorbates (Fig. 1), and is induced by intervalley scattering of electrons. The interference effect shows an energy dependence which corresponds to the conical band structure of graphene. Moreover, a simultaneous imaging of the electronic scattering pattern and the atomic structure enables the determination of the impurity position with respect to the crystal lattice.

Employing tip-graphene interactions, we move parts of the flake under the tip vertically [1]. Thereby, we also modify the atomic lattice of graphene, observing a phase transition between a hexagonal and a buckled, threefold symmetry phase. Different models, including mechanical compression and modifications of the local density of states, are discussed.

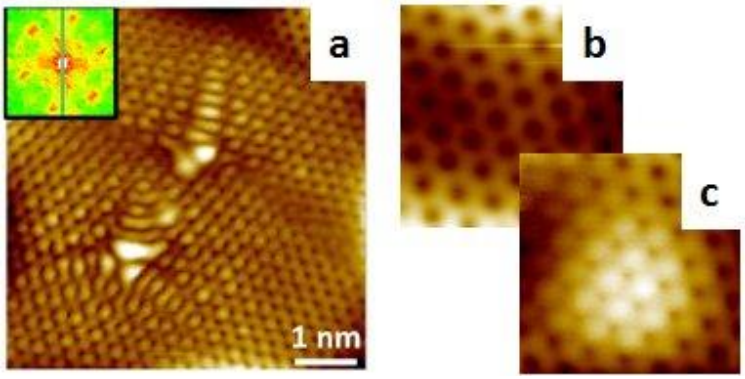

Fig. 1: STM constant current images of (a) scattering patterns at an adsorbate, (b) hexagonal contrast at 0.5 V, 0.1 nA (larger tip-sample distance), (c) trigonal contrast at 0.5 V, 5 nA (smaller distance).

References

[1] T. Mashoff, M. Pratzer, V. Geringer, T. J. Echtermeyer, M. C. Lemme, M. Liebmann, and M. Morgenstern: *Bistability and Oscillatory Motion of Natural Nanomembranes Appearing within Monolayer Graphene on Silicon Dioxide.* Nano Lett. **10**, 461 (2010).