Doping graphene with Nitrogen: an STM study

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Tuning the electronic properties of graphene is necessary in order to broaden its possible field of applications. In microelectronic devices, such as field transistors, the active material for the transport layer needs the presence of an energy gap by which the conducting behavior of electrons or holes as charge carriers can be controlled with the voltage [1].

In this context, theoretical studies ([2,3]) have shown that different doping configurations of graphene with nitrogen would shift the Fermi level away from the Dirac point and induce a valence-conduction bands asymmetry. STM images have been simulated for various kinds of doping (substitution, pyridine like bonding,...) [3].

According to literature [4-7], graphene can be obtained by annealing a 6H SiC (000-1) single crystal. In our work, we exposed SiC at 850 °C to a Si flux, followed by annealing at 950 °C to produce a 3x3 reconstruction. Finally, annealing at 1080°C resulted in the graphene formation. STM operating at room temperature showed Moiré patterns as reported in [5,6] and atomic resolution was achieved revealing the typical honeycomb structure (figure 1).

The sample was then exposed to a flux of atomic nitrogen produced by a remote plasma source. After nitrogen exposure, several defects were created on the originally defect-free graphene surface. As shown on figure 2, the overall shape of a single typical defect presents a localized triangular pattern of 1 nm size. Variations of the pattern with bias voltage have been observed (figure 2).

With the support of Density-Functional Theory, we tentatively attributed the observed pattern to pyridine-like doping (figure 3). Similarities and differences between experimental data and more theoretical simulations are to be discussed during the talk.

References:

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Figures:

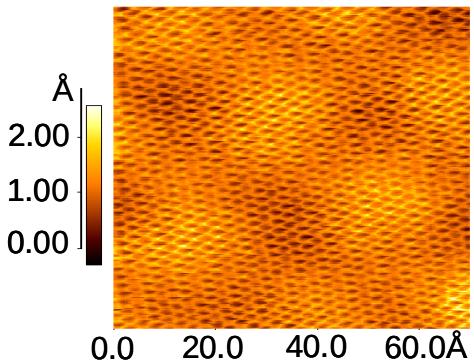


Figure 1: Graphene (V_s = -0.5V; I = 3nA)

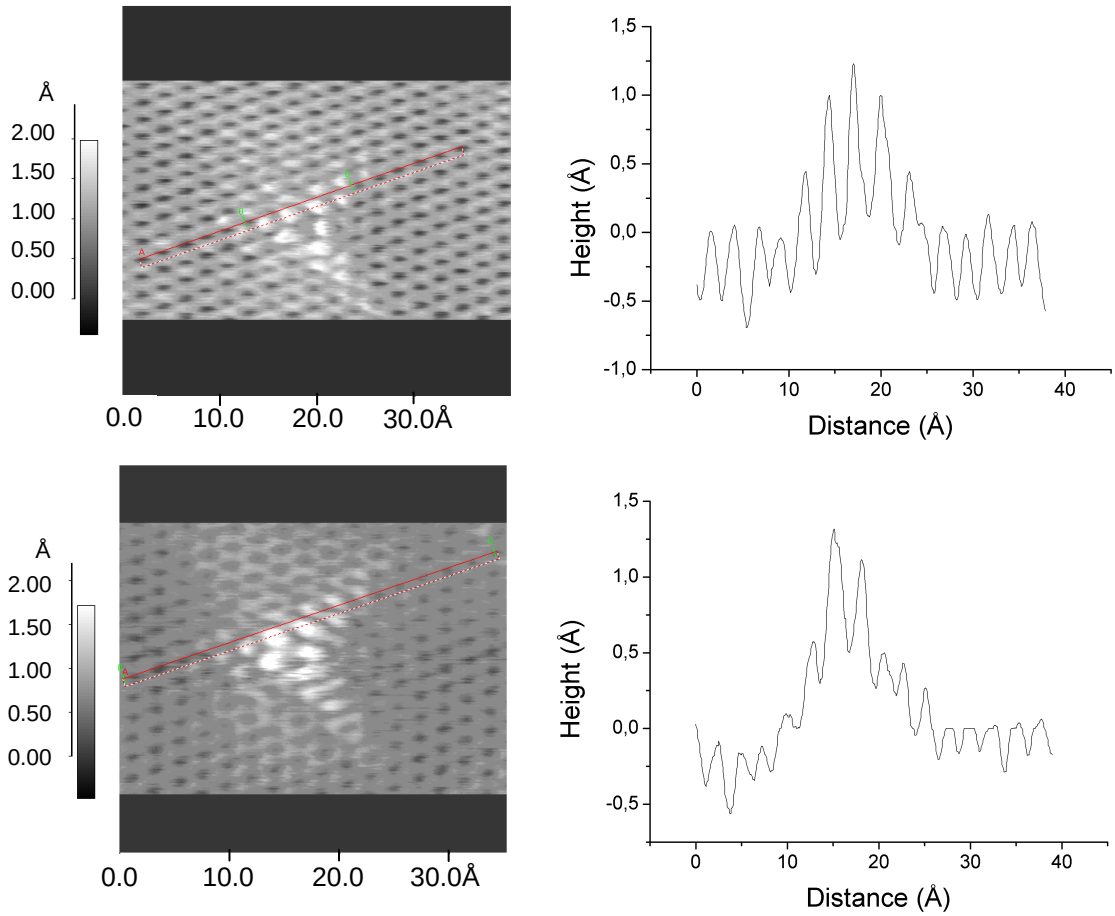
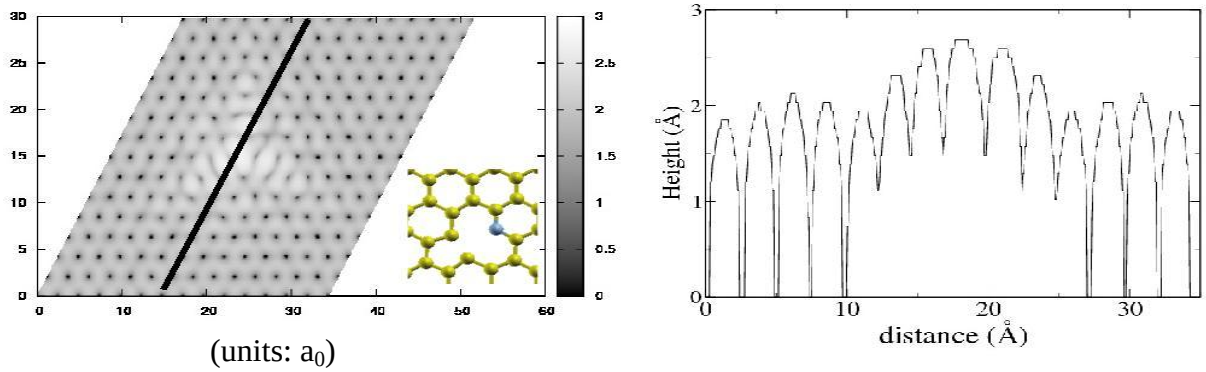


Figure 2: I=8nA. Above: V_s=+0.5V; below: V_s=-0.5V



(units: a_0)

Figure 3: STM simulation of a pyridine-like N-doping (V_s = + 0.5 V)