Nitrogen doping of graphene studied by scanning tunneling microscopy

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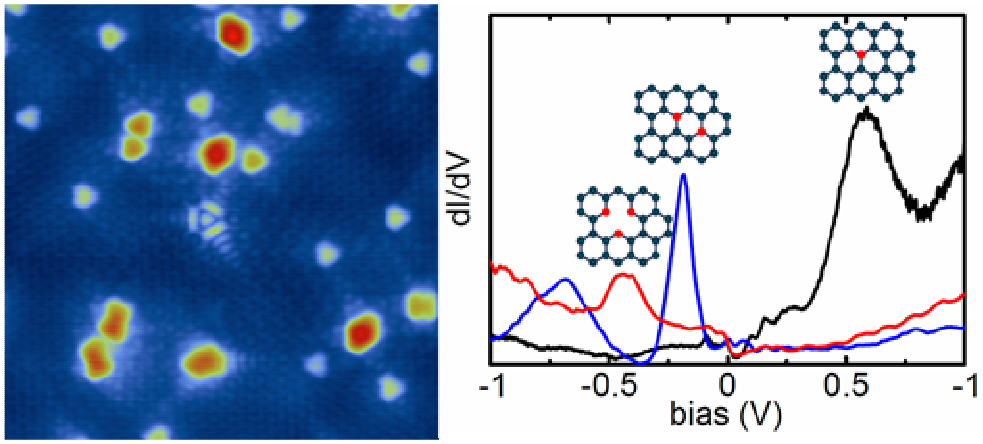
Abstract
Tuning the electronic properties of graphene is a key to the development of carbon-based electronics or other applications taking advantages of the properties of this 2D-material. Among the possible strategies to achieve this goal, the insertion of nitrogen atoms in the carbon lattice appears to be particularly interesting as it allows to perform regular doping with minimal atomic relaxation. Several studies have focused on the properties of nitrogen doped graphene down to the atomic scale using scanning tunneling microscopy (STM).
Here we report on the systematic investigation of nitrogen doped graphene on SiC(000-1) using STM and scanning tunneling spectroscopy (STS). The spectroscopic measurements show that the doping induces a shift of the Dirac point that does not follow the expected behavior from a rigid band model. This point will be discussed. In addition to single substituted nitrogen the inserted atoms can have different local environments: pyridinic where the nitrogen is combined with a vacancy, and pairs of nitrogen with different interatomic distances (see figure). The isolated single nitrogen atoms have been found to be the most common characterized by a localized resonance in valence band [1]. On nitrogen pairs, the local density of states is different from that of single graphitic nitrogen suggesting that an electronic interaction occurs between N atoms even when they are separated by several atomic sites. The properties of these complex atomic configurations will be shown and discussed.

The extensive measure by STM/STS of N-doped graphene allow to provide a detailed background to better understand the electronic properties of chemically doped graphene.

References
[1] F. Joucken et al., Phys; rev. B, **85** (2012) 161408 (R).

Figure :



STM image of nitrogen doped graphene revealing different atomic configurations of the doping sites. Local spectroscopy showing the difference between spectra measured on different types of doping sites.