Epitaxial Graphene On 4H-SiC(0001) Grown Under Nitrogen Flux: Evidence Of Low Nitrogen-Doping And High Charge Transfer

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Abstract

Since its discovery, graphene has attracted tremendous interest and its unusual properties make it a promising candidate for future electronic and optic applications [1]. Along the view of designing graphene-based devices, many efforts are devoted nowadays to the achievement of large scale graphene patterning in a reproducible way with controlled structural quality. Among the various ways to produce graphene [2], the growth of graphene layers on silicon carbide (SiC) is a very promising method for homogeneous large scale production with a high crystalline quality, as it has recently been demonstrated [3]. On the Si face, the first carbon layer presents a honeycomb structure but do not evidence the expected graphitic electronic properties [3, 4]. This is mainly due to the remaining one-third carbon atoms that are strongly bonded to the Si atoms of the substrate at the interface. This first layer acts therefore as a buffer layer and promotes the growth of the following carbon layer, i.e. the first layer to behave, from an electronic point of view, as an isolated graphene sheet. However, the Si dangling bonds that remain trapped at the interface below the buffer layer are responsible for high intrinsic electron doping of graphene and hinder the carrier mobility. Doping the graphene can modify the electronic properties, by opening a bandgap at the K point, which is of prime importance for optoelectronic and nanoelectronic applications. Doping with nitrogen has been considered as an effective approach to fabricate n-type graphene materials.

In this contribution, we present the structural and electronic properties of N-doped epitaxial graphene on SiC(0001). Low Energy Electron Microscopy (LEEM) and Low Energy Electron Diffraction (LEED) demonstrate the excellent crystallinity of our graphene samples. These N-doped samples have been studied using X-ray Photoemission (XPS), Angle Resolved Photoemission Spectroscopy (ARPES) and Near Edge X-ray Absorption Fine Structure (NEXAFS) at the synchrotron SOLEIL. The XPS spectra show at least three types of nitrogen doping sites: graphitic, pyridinic and pyrrolic nitrogen (fig. 1). These experiments also demonstrate that we performed a low nitrogen-doping on our samples inducing an important change on the density charge (fig. 2) [5].

References

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Figures

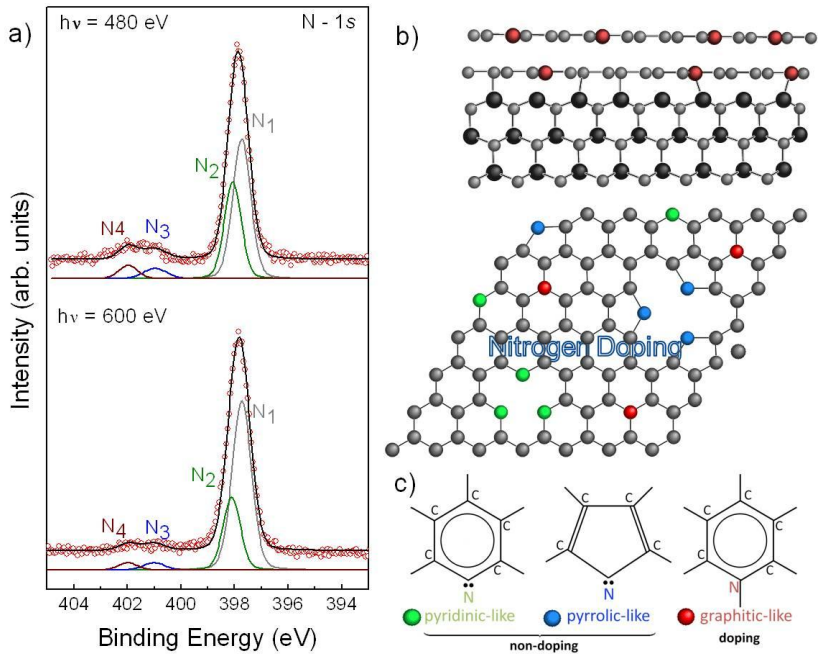

Figure 1: (a) High-resolution N-1s spectra of the nitrogen doped graphene at hν=480 eV (surface sensitive, top panel) and N-1s at hν=600 eV (bulk sensitive, bottom panel). (b) Sketch of nitrogen-doped graphene with the four suggested doping sites, i.e., graphitic, pyrrolic and pyridinic nitrogen and Si-N formation (c) different configurations of N-doped graphene layer.

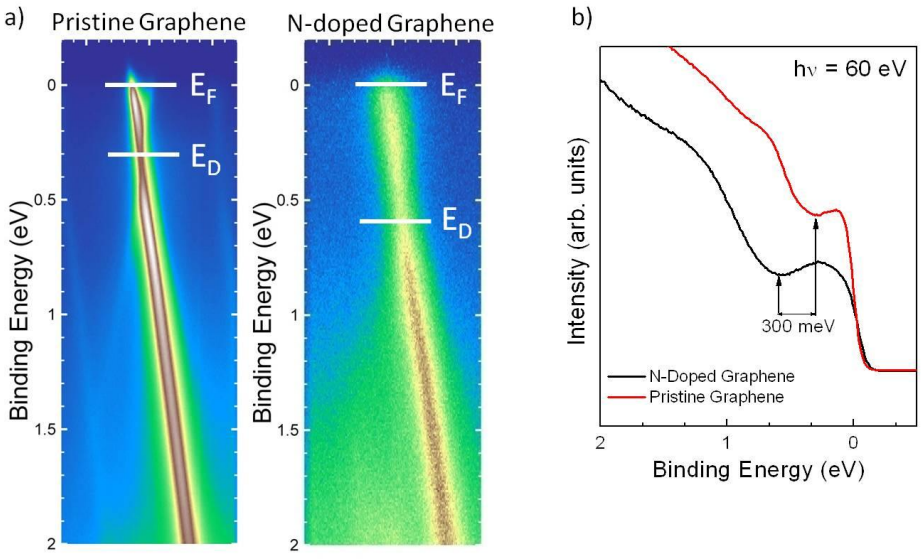

Figure 2: (a) ARPES at room temperature of pristine graphene and N-doped graphene/SiC(0001), measured at hv = 60 eV, through the K-point, along to the ΓK direction; (b) ARPES intensity integrated spectra as a function of the binding energy, extracted from the 2D ARPES map, for the initial pristine graphene (red line) and N-doped graphene (black line).