Investigation of Graphene/Ge(110) interface

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Investigating the interfacial properties between graphene and traditional semiconductors is crucial to develop novel electronics [1]. In this framework, the Graphene/Ge(110) has received a great deal of attention over the last couple of years [2–7]. These studies focus on the structure of Graphene/Ge(110) interface and notably on the possible reconstructions of Ge surface as shown by scanning tunnelling microscopy (STM). However, no insights into the electronic properties of this interesting system are today available.

Here, we investigate the evolution of the system´s interface upon annealing in vacuum at different temperatures. We use low-temperature STM to probe the surface structure with atomic precision. At each stage, images at different applied biases are collected and interestingly, graphene becomes transparent at high biases. When growing graphene by chemical vapour deposition, hydrogen that is used during growth passivates the Ge surface, stabilizing the (1x1) phase (i.e., unreconstructed surface) [5]. Annealing the sample at 350°C leads to desorption of hydrogen and STM and low energy electron diffraction (LEED) reveal that the surface of Ge(110) reconstructs into a (6x2) phase, never observed for bare Ge. Upon further annealing above 700°C, STM shows that the Ge surface modifies back into the (1x1) phase. At this point, due to the lack of hydrogen, the (1x1) is stabilized by graphene forming chemical bonds with Ge atoms underneath [2]. Indeed, the Ge surface remains in the (1x1) phase even if further annealing at temperature above 350°C is performed. To gain insights into the electronic properties, we perform angle resolved photoemission spectroscopy (ARPES) after each thermal annealing step. The ARPES data show how graphene´s doping changes upon thermal annealing, signature of a different interaction with the Ge substrate (Figure 1).

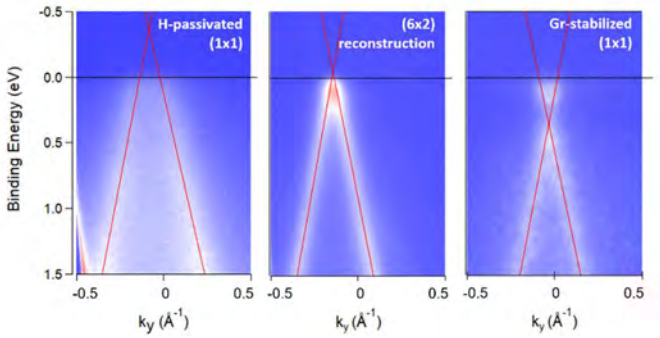

Figure 1. ARPES intensity maps of Gr/Ge(110) samples as grown (left), annealed at temperature below (middle) and above 800 °C (right). The shift of the Dirac point as a function of the annealing temperature is evident.

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Supplementary Pages (Optional)

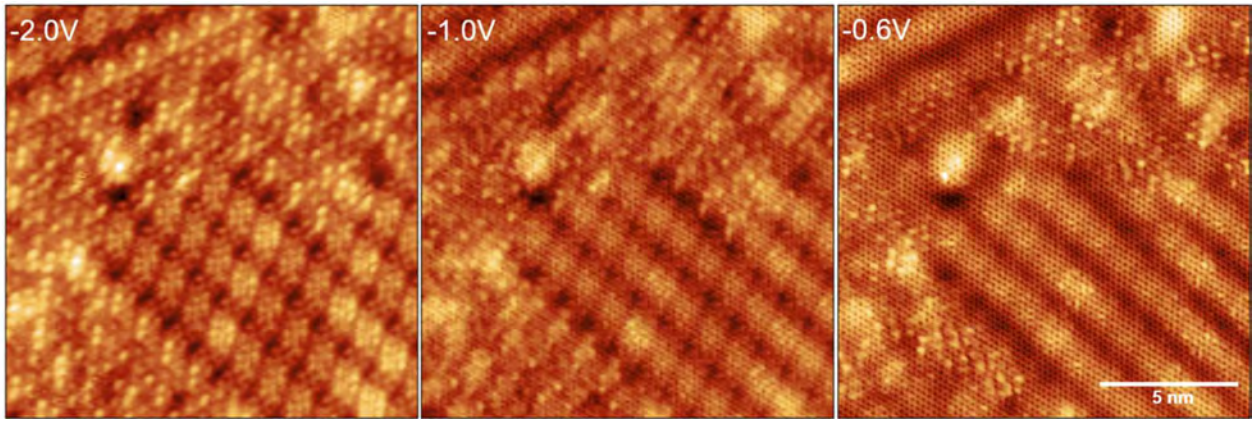

Figure S 1. STM images of the same area collected at different bias voltages after annealing at 350°C and showing both the (6x2) reconstruction and the (1x1) phase. I= 0.3nA. The surface topography exhibits strong bias dependence. For high biases, graphene becomes transparent to tunneling and this allows the visualization of the underlying Ge surface.