
We present here the study of the growth of epitaxial graphene islands and complete monolayers on a Ru(0001) substrate and its reactivity towards oxygen and air. The graphene is prepared by thermal decomposition at 1000 K of ethylene molecules pre-adsorbed at 300 K on a Ru(0001) surface on an ultra high vacuum chamber. The difference in lattice parameter between graphene and ruthenium induce a rippled structure in graphene with a triangular periodicity of 2.4 nm. The periodic ripples produce spatial charge redistribution in the graphene. This have been measured with spatially resolved dI/dV scanning tunnelling maps and confirmed with a theoretical model [9].

The growth method described here can be used to produce nanometer wide islands on terraces or a complete monolayer of graphene. The islands are truncated hexagons with straight edges of a single structural type (fig1a). The apparent step height of the island in these imaging conditions is 0.15 nm (from the Ru surface to the lower part of the ripples) showing that the graphene layer is indeed only one monolayer. The relative orientation of the graphene layer with respect to the underlying Ru lattice can be determined by resolving simultaneously both atomic lattices. A complete monolayer can be produce by repetitive procedures of thermal decomposition. The monoatomic steps and dislocations of the substrate are faithfully reproduced by the epitaxial graphene, but there are also upper parts of the ripples that are weaker or even missing completely.

In order to investigate the reactivity of graphene we expose graphene islands grown on Ru(0001) to a partial pressure of oxygen and following the evolution of the surface by STM in real time. It is well known that exposure of clean Ru(0001) surface to partial pressures of oxygen lead to the formation of a 2x2 superstructure of oxygen atoms on the Ru(0001) surface. For a exposure during 3 minutes to a pressure of 5x10^{-8} Torr the 2x2 oxygen superstructure is already form [10] but the graphene structure, even the borders of the islands, remain intact as can be seen in the fig1b. There is no change in this behaviour upon increasing the oxygen partial pressure or the exposure time. A similar study was performed by exposure to air. STM images were recorded before and after exposing the sample during 12 hours to 1 atmosphere of air. The surface areas not covered by the graphene islands present a dramatic change, before the exposure to air the surface was flat and atomically clean and after the exposure the ruthenium surface is completely covered by irregular bumps due to contamination. On the contrary the graphene islands presented on the surface did not change after the air exposure. In the case of a complete graphene monolayer the exposure to oxygen or to air does not affect or destroy the rippled structure of the graphene monolayer.
References:


Figures 1: 18 nm x 18 nm STM images showing the edge of a graphene nanoisland on Ru(0001), taken in the constant current mode with a bias voltage of -0.9V and tunnel current of 0.1 nA, before (a) and after 4 minutes of exposure to a partial pressure of 5x10⁻⁸ Torr of oxygen (b)