Scanning Tunneling Microscopy Analysis of Unusual Moiré Patterns on Graphene on Rh(111) Grown under Ultra-High Vacuum Conditions

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The growth of graphene on transition metals by means of different procedures has been highly studied in recent years [1, 2]. The main reason why so many efforts have been devoted by the scientific community to study this kind of systems is to understand the interactions between the two dimensional carbon layer and the metal underneath. These interactions do not only change the electronic properties of graphene, but also its geometrical structure which leads to moiré periodic superstructures.

It has been found that, if the graphene-metal interaction is low enough, more than one moiré lattice is stable for the same graphene-metal system. In the particular case of graphene grown on Rh(111), this interaction is not considered to be low [1]. Therefore, only one relative orientation of the carbon atom lattice with respect the Rh(111), leading to only one moiré pattern, has been described [3-6]. It is the (12x12) C on (11x11) Rh(111) moiré, in which the carbon lattice is aligned with the metallic one and also with its superstructure.

In this study, we report on the growth of graphene on Rh(111) and the formation of several different moiré structures. The experiments have been performed in ultra-high vacuum (UHV) by means of variable temperature scanning tunneling microscopy (VT-STM). Also, the graphene monolayer has been grown on the Rh(111) single crystal in UHV via chemical vapor deposition (CVD) of low pressure ethylene (C_2H_4).

As a result, we have observed the usual (12x12) C on (11x11) Rh(111) moiré which has been already found in previous works (fig. 1), but also several other rotational epitaxial graphene domains (fig. 2). From these data, a relationship between the superstructures' corrugation and its periodicity has been found. Finally, using this relationship, we compare our experimental results with a simplified model in which both structural and energetic properties of the different moirés have been taken into account.

References

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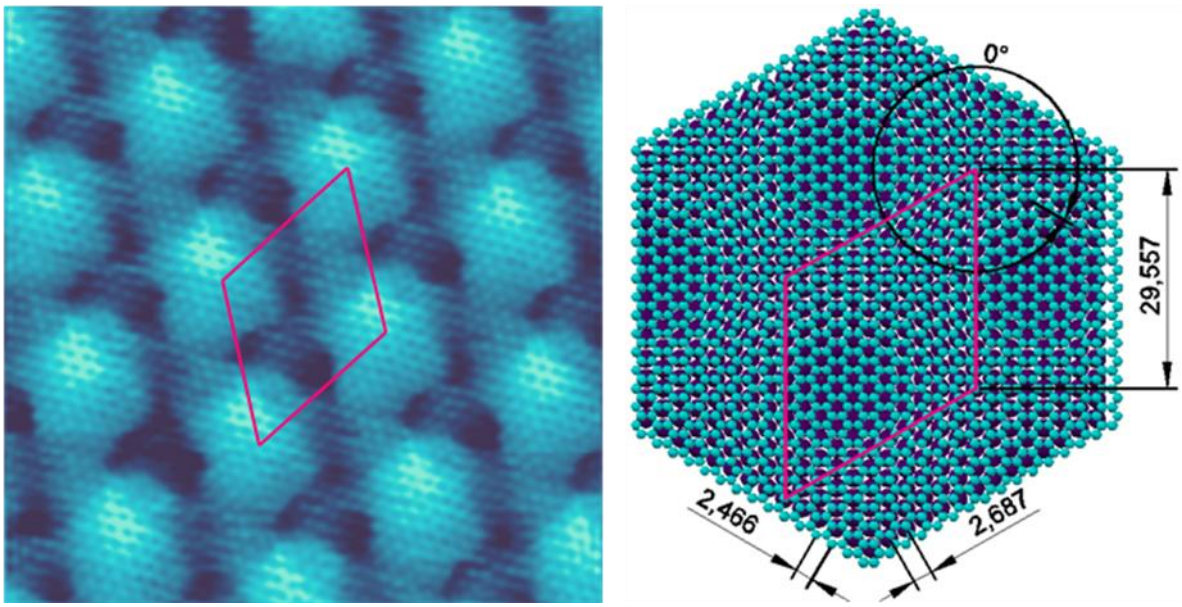

Figure 1. (10x10) nm^2 STM image where the carbon atoms position with respect the (11x11) Rh(111) moiré can be observed and compared with its model on the right part of the figure. V_S= -400mV, I_T= 2nA. The distances in the model are set in Å.

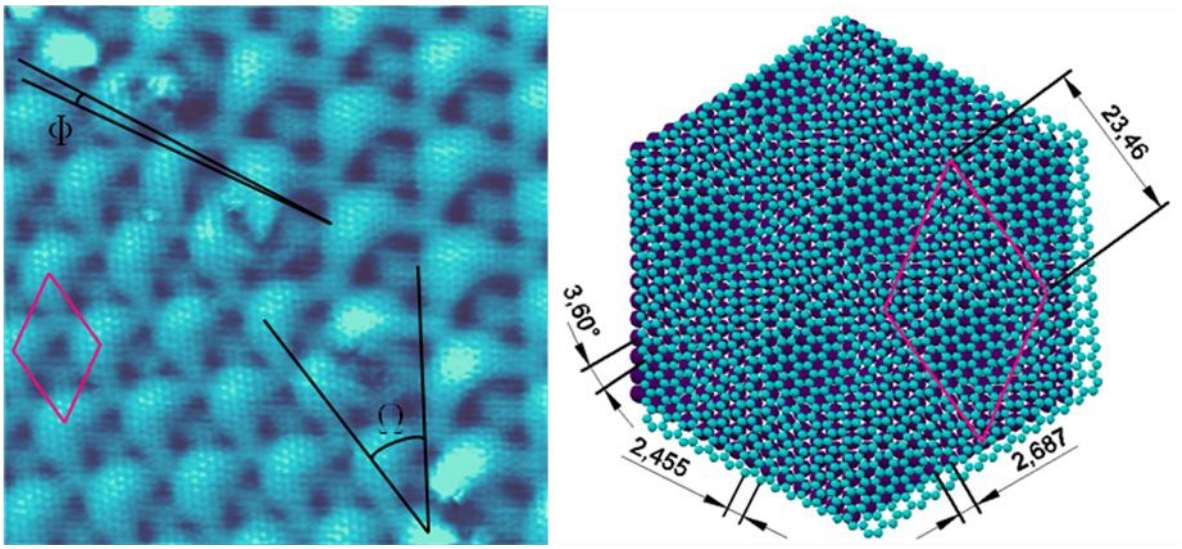

Figure 2. (15x15) nm^2 STM image where two different moiré patterns with atomic resolution can be observed: on the right-top part of the STM image the (12x12) C on (11x11) Rh(111) moiré, and on the left-bottom part, a new different moiré pattern. Comparing the angles between both moirés (Ω) and between the carbon atoms in both flakes (Φ), a model for the new moiré superstructure has been obtained. V_S= -300mV, I_T= 19nA. The distances in the model are set in Å.