

Vázquez de Parga *et al.* Reply: The Comment by B. Wang *et al.* [1] states that according to their *ab initio* calculation, the periodically rippled graphene monolayer epitaxially grown on Ru(0001), whose spatially resolved electronic structure we unravelled recently [2], presents a large (0.15–0.17 nm) *geometrical* corrugation. They further state that this contradicts our structural model of a flat, van der Waals-bonded graphene layer [2].

We never mention in our Letter [2] that the actual graphene monolayer on Ru(0001) was geometrically flat, nor that the Ru-C interaction was van der Waals-like. Quite on the contrary, a geometrical corrugation is expected to occur, as it happens with incommensurate overlayers on almost all surfaces [3], but we highlighted the *additional* electronic contribution to the corrugation.

In order to show that *any* periodic potential applied to the graphene layer will result in periodic charge inhomogeneities, as revealed by local tunnelling spectroscopy, we described in [2] a very simple model calculation, in which a flat, isolated graphene monolayer under the influence of an adjustable 2D periodic potential showed the appearance of electron and hole pockets, as detected in the Scanning Tunneling Spectroscopy experiment. We never claimed that this flat isolated graphene monolayer reflected the actual geometry of the graphene or Ru(0001) case.

The fact that our simple tight binding calculation shows both the appearance of superlattice effects and the spatial separation of occupied and empty states in agreement with experiment indicates that the effect is robust and of quite general nature [4]. In effect, the periodic potential could be applied to the graphene monolayer by different physical means: a periodic variation of the interaction potential with the substrate caused by modulation of the perpendicular C-Ru distances, an external voltage applied with nano-fabricated gates, or the ordered adsorption of donor or acceptor molecules.

We, thus, maintain that in addition to a certain degree of geometric modulation of the perpendicular C-Ru distances unavoidable by geometrical constraints, there is a spatially modulated charge redistribution, detectable by STS. This is not only directly seen in the spatially resolved STS maps, but it is also reflected in the voltage dependence of the apparent corrugation of the ripples, briefly mentioned in Ref. [2] and shown in more detail in Fig. 1. The corrugation of the ripples in graphene on Ru(0001) changes from 0.11 nm at -0.8 V to 0.05 nm at $+0.8$ V. The corrugation is larger when sampling the occupied electronic states because of the charge accumulation in the upper part of the ripples. It becomes smaller when sampling the empty density of states, since the empty states accumulated at the lower part of the ripples, as shown also in Fig. 3 of Ref. [2].

Notice that the geometrical corrugation calculated by Wang *et al.* [1] (0.15–0.17 nm) is substantially larger than

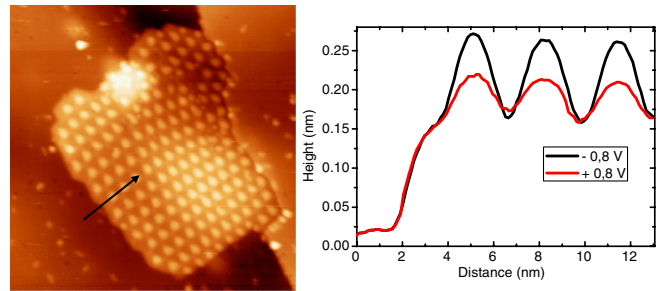


FIG. 1 (color online). Left panel: STM image of a graphene island grown on Ru(0001) surface. Right panel: Two representative line profiles of the island measured at different bias voltages.

the largest experimental value (0.11 nm). This, together with the fact that the calculated spatially resolved DOS, which correctly predicts the asymmetry between occupied and empty states, does, however, predict the existence of peaks in the DOS not in agreement with our STS data [2], indicates that the calculation reported in [1] is not quantitatively consistent with some of our observations and calls for a precise experimental determination of the extent of the geometrical buckling in the system.

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