Graphene growth by “magical sizes” graphene nanoclusters assembly on Re(0001)

Artaud A.[123], Ratter K.[234], Gilles B.[4], Bendiab N.[23], Magaud L.[23], Coraux J.[23], Chapelier C.[1]

[1]INAC-SPSMS, CEA, 17 rue des Martyrs, F-38054 Grenoble cedex 9, France
[2]Institut NEEL, CNRS and Université Joseph Fourier, BP166, F-38042 Grenoble Cedex 9, France
[2]Universite´ Grenoble Alpes, Inst NEEL, F-38042 Grenoble, France
[3]CNRS, Inst NEEL, F-38042 Grenoble, France
[4]SIMAP, Grenoble INP, 1130 rue de la Piscine, BP 75, F-38402 Saint-Martin-d’Hères Cedex, France
Contact: alexandre.artaud@neel.cnrs.fr

Abstract:

Monolayer graphene shows unique electronic properties, among which ballistic electronic transport at the micrometer scale [1]. This makes graphene an ideal candidate for coherent Cooper pair transport via Andreev Bound States (ABS) between two superconducting reservoirs. Whereas evidence of a supercurrent in graphene has been given as soon as 2007 [2], no signature of ballistic ABS was found yet, due to low transparency of the graphene-superconductor interface and extrinsic disorder induced by the fabrication of the junction or by its environment.
These problems can be circumvented by growing graphene epitaxially on a superconducting substrate such as Re(0001) (gr/Re). In this system, superconducting correlations have been measured using scanning tunneling microscopy-spectroscopy (STM/STS) [3].

Gaining control over graphene growth on Re(0001) is mandatory in view of designing advanced graphene-superconductor epitaxial systems, such as graphene billiards and perpendicular-to-the-plane junctions with tunable graphene doping and interaction with the metal. With the help of STM and reflection-high energy electron diffraction performed in situ, in the same ultra-high vacuum where the sample has been prepared, we have explored the nucleation and first steps of the growth of gr/Re. We have found that graphene coexists with a dilute carbon phase forming a surface reconstruction, and that graphene nanoclusters of well-defined sizes (“magical sizes”) preferentially form (Figure 1). These “magical sizes”-nanoclusters are mobile and assemble to form graphene sheets [4].
They are therefore the key-intermediate to grow graphene, though their formation has only been predicted thus far. Our density functional theory calculation (Figure 2a,b) help us deciphering their electronic and structural properties.

References:

[1] Mayorov *et al.*, Nano Letters, **12** (2012) pp.4629-4634
[2] Heersche *et al.*, Nature, **446** (2007) pp.56-59
[3] Tonnoir *et al.*, Physical Review Letters, **111** (2013) 246805
[4] Artaud *et al.*, to be submitted

Figures:

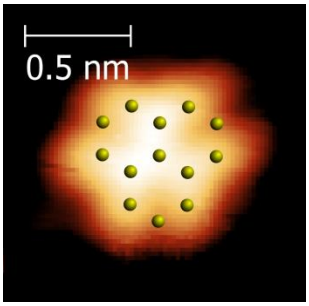
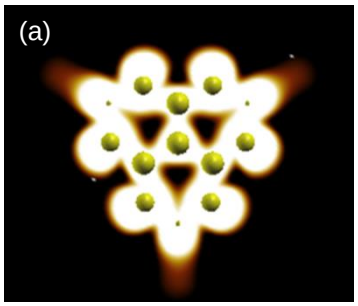


Figure 1:
STM topograph (1.4×1.4 nm) of a typical 3-C6 graphene nanocluster on Re(0001).



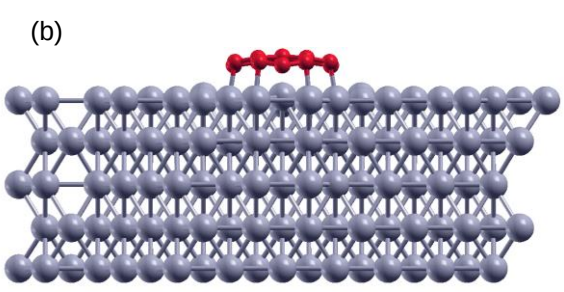


Figure 2:
DFT-simulated 3-C6 graphene nanocluster on a (7×7) cell of Re(0001).
(a) Integrated $|\psi|^2$ over the $0 - 0.2$ eV range. C atom sizes are proportional to their distance from the Re surface.
(b) Side-view showing the dome-like shape of the graphene nanocluster.