Epitaxial graphene nano flakes on Au(111): Structure, electronic properties and manipulation

Julia Tesch[1], Philipp Leicht[1], Luca Gragnaniello[1], Lukas Zielke[1], Riko Moroni[1], Samuel Bouvron[1], Elena Voloshina[2], Lukas Hammerschmidt[3], Lukas Marsoner Steinkasserer[3], Beate Paulus[3], Yuriy Dedkov[4], and Mikhail Fonin[1]

[1] Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany
[2] Institut für Chemie, Humboldt Universität zu Berlin, 12489 Berlin, Germany
[3] Institut für Chemie und Biochemie, Freie Universität Berlin 14195 Berlin, Germany
[4] SPECS Surface Nano Analysis GmbH, 13355 Berlin, Germany
julia.tesch@uni-konstanz.de

Abstract

Confinement of electrons in graphene quantum dots and nanoribbons presents an exciting field of research, owing to predicted peculiar electronic and magnetic properties [1,2]. Recent attempts with the purpose of measuring the properties of graphene nano dots (GNDs) on Ir(111) have revealed detrimental edge bonding of graphene to the employed iridium substrate [3,4]. We have developed an in-situ fabrication method of graphene nano flakes (GNFs) on the Au(111) noble metal surface. We show that this system is well-suited for STM investigations of the structural and electronic properties of epitaxial GNFs.

In the present work, the preparation of GNFs was performed by a two-step process. First well-shaped graphene flakes of different sizes down to several nanometers are prepared on the Ir(111) substrate by temperature programmed growth [5]. Second, a 5 nm thick Au layer is deposited on top of the sample followed by high temperature annealing, yielding embedded and floating GNFs on a high-quality Au(111) surface.

We show that flakes can be easily displaced across terraces at room temperature utilizing the STM tip if flakes are initially detached from the Au terraces. The tip-induced displacement of flakes is observed regardless of GNF size by scanning with appropriate tunnelling parameters. Furthermore, eminent quantum interference patterns are observed at the flake edges and compared to DFT calculations of freestanding graphene in order to elucidate edge terminations of the graphene flakes. We observe predominantly single hydrogen terminated, unreconstructed graphene edges, often including long zigzag segments.

The electronic properties of the graphene flakes can be accessed via Fourier transform scanning tunnelling spectroscopy (FT-STS). Exploitation of the scattering at defects and edges in the FTs of energy selective local density of states mappings of the graphene honeycomb lattice allows the determination of electronic properties, such as the dispersion relation. For GNFs on Au(111) we measured the expected linear electronic dispersion relation close to the Dirac point which is shifted towards the unoccupied states.

References

[1] K. Nakada, M. et al., Phys. Rev. B **54** (1996) 17954
[2] O. V. Yazyev, Rep. Prog. Phys. **73** (2010) 056501
[3] D. Subramaniam et al., Phys. Rev. Lett. **108** (2012) 046801
[4] S. J. Altenburg et al., Phys. Rev. Lett. **108** (2012) 206805
[5] J. Coraux et al., New J. Phys. **11** (2009) 023006

Figures

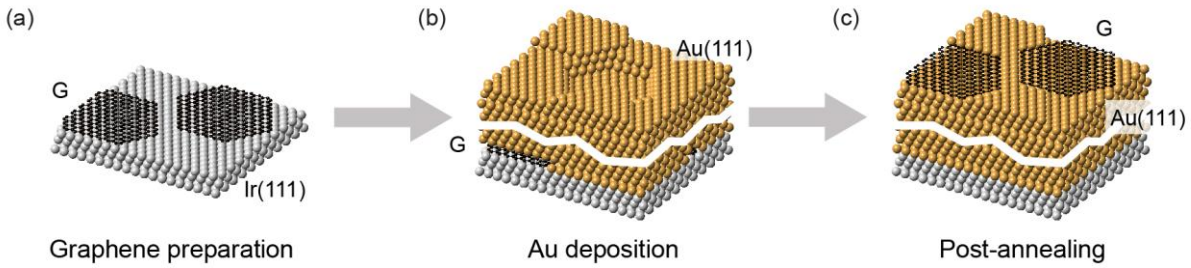

Figure 1: Schematic of graphene nano flake formation on Au(111).

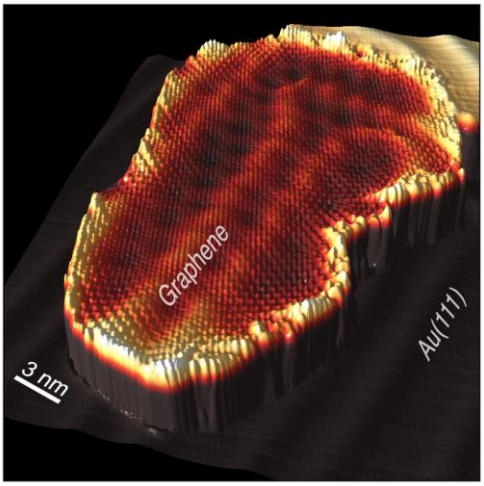

Figure 2: 3D topographic image of quasi-freestanding graphene flake on Au(111). Image shows herringbone reconstruction and moiré as well as quantum interference at the edges.