

Chemical vapor deposition growth and characterization of graphene on Rh(111) and Ir(111) single crystals

N. Kelaidis¹, A. Kordatos¹, P. Tsipas¹, E. Xenogiannopoulou¹, J. Marquez-Velasco¹, S.A. Giamini¹ and A. Dimoulas¹

¹Institute of Nanoscience and Nanotechnology, National Center for Scientific Research “DEMOKRITOS”, 15310, Athens, Greece
[Contact@E-mail: nkelaidis@ims.demokritos.gr](mailto:nkelaidis@ims.demokritos.gr)

Abstract

Few studies exist on graphene on Rh(111) single crystal substrates [1,2]. Graphene on Ir(111) has been studied more, but in both cases the usual mode of preparation is under Ultra High Vacuum (UHV). In this study, we perform Chemical Vapor Deposition (CVD) of graphene on Ir(111) at 1200° C and Rh(111) at 1000°C using methane (CH₄) as the carbon precursor at low and atmospheric pressure respectively (non-UHV conditions). Due to the high carbon solubility of the catalytic substrates a moderate cooling rate is preferred. Graphene covers the whole surface in both cases. Structural characterization by ARPES, STM and RAMAN is performed.

Few layer graphene is grown on Rh(111) single crystal. The electronic band structure as investigated by ARPES at room temperature shows the valence band structure imaging of the system along the Γ K direction of Rh(111) surface Brillouin zone (Fig. 1(a)). Graphene's σ and π bands are observed with σ -bands dispersing from 4eV binding energy at Γ -point downwards along Γ K, while π band disperses from 8.5eV binding energy at Γ -point upwards up to Fermi level at 1.703 \AA^{-1} , forming a Dirac cone at K_{GR} -point. Detail of the APRES constant energy contour k_x - k_y is shown in Fig. 1(b). Good epitaxial orientation is observed in agreement with RHEED data (not shown here) where Γ K direction of graphene is aligned with the Γ K direction of Rh(111). Single layer graphene is grown on Ir(111) single crystal and studied by STM (Fig.1(b)). A well-structured honeycomb lattice is observed. The bright points correspond to higher regions whereas the dark areas correspond to shallower regions. The high quality graphene extends to the whole scanning area surface. Raman characterization spectra (not shown here) lack the typical imaging because of the high noise/signal ratio.

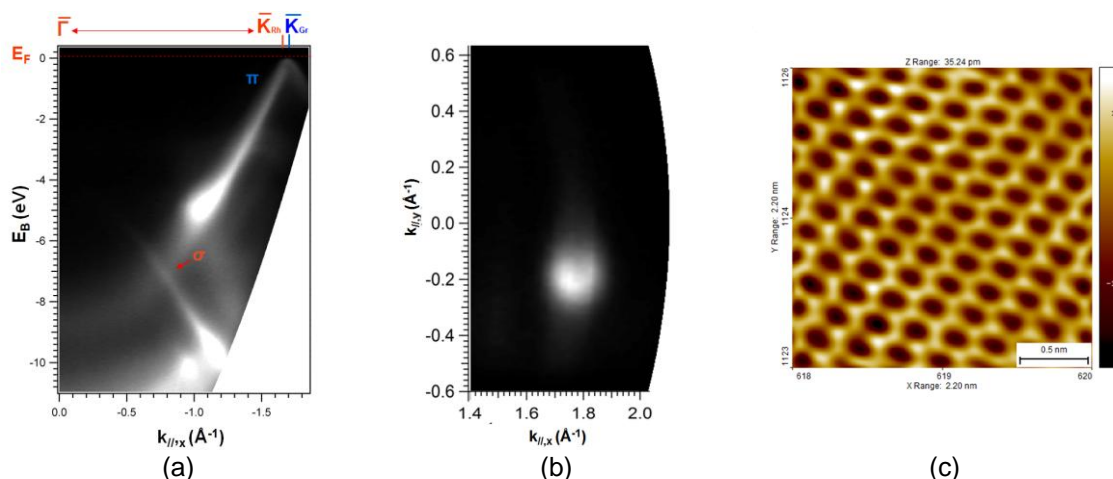


Figure 1: (a) ARPES imaging (He-I 21.22eV) of the valence band structure for Graphene on Rh(111) along the Γ K direction of Rh(111) surface Brillouin zone (SBZ). The π -band disperses linearly up to Fermi level at K_{GR} point. (b) Detail of the APRES constant energy contour k_x - k_y plot. (c) HRSTM imaging ($2.2 \times 2.2 \text{ nm}^2$) of the crystallographic structure for the Graphene on Ir(111) system.

Acknowledgements: ERC AdG SMARTGATE (Grant No 291260)/ Greek Program for Excellence ARISTEIA-TOP-ELECTRONICS (Grant No. 745).

References

- [1] Mengxi Liu, Yanfeng Zhang, Yubin Chen, Yabo Gao, Teng Gao, Donglin Ma, Qingqing Ji, Yu Zhang, Cong Li and Zhongfan Liu, ACS Nano, **6** (2012), 10581.
- [2] G C Dong, D W van Baarle, M J Rost and J W M Frenken, New Journal of Physics, **14** (2012), 05303
- [3] Choon-Ming Seah, Siang-Piao Chai, Abdul Rahman Mohamed, Carbon, **70** (2014), 1.