Graphene monolayer produced on Pt reusable substrates for transparent conductive electrodes applications.

L.Golanski, D.Rouchon, H. Okuno, J.Dijon, E.Quesnel, P.Fugier

CEA, MINATEC Campus, F-38054 Grenoble, France
luana.golanski@cea.fr

Abstract

Large-scale growth of graphene materials by CVD is commonly realized on Cu substrates for transparent conductive electrodes applications [1]. However, this Cu-based technology induces chamber pollution difficult to clean and not compatible with further microelectronic processing. In this work, we report on a graphene production process using CVD technique on Pt thin film covered substrate. Considering the cost ratio between platinum and copper we just need to reuse the substrate 20 times to be cost effective as compared with copper foil use. As compared with growth on Cu films the graphene grown on Pt films exhibit only few ripples thanks to the lower substrate temperature and smaller coefficient of expansion of Pt as compared with Cu. We developed a growth process allowing high quality graphene single layer using an microelectronic industrial tool able to deposit graphene on 200mm substrates. Growth was achieved by catalytic decomposition of CH_4 at a very low CH_4/H_2 flow rate ratio in order to lower the nucleation density of graphene on Pt and favor large graphene grains on Pt. Graphene production with nucleation control is obtained on Pt thin film substrates at 800°C compared to 1000°C for Cu. In these conditions, grains with typically tenth of µm size are obtained. Each grain is formed with high quality single crystal without any obvious atomic defect as seen by HRTEM (Figure 1a). In order to better assess the graphene quality, Raman spectra were acquired and Raman mapping performed (Figure 1b). The intensity ratio (IG / I2D) around 0.3 testify that the deposited graphene is made of a single layer at least on the area tested (25x25µm) [4].
For further integration of graphene into applicative devices, a clean transfer from metal substrates preserving the integrity of graphene sheet, remains a challenge that needs to be overcome [1]. We tested two non-destructive transfer techniques which should allow to re-use the Pt substrates, such as an electro-chemical method [2] or a dry transfer approach [3]. Graphene sheets transferred by electro-chemistry showed a good quality: density of defects such as cracks, holes are minimized. Moreover, after the electro-chemical transfer, TEM analysis confirmed only quite few metal contamination less than with graphene obtained by conventional Cu dissolution transfer method. As dry transfer, the delamination of a graphene monolayer by the stress accumulated in Ni films has been also tested to transfer graphene grown on Pt substrate. The sheet resistance of a monolayer of graphene transferred on glass by an electrochemical process is around R_S = 1300 Ω/square (four point method). By improving this route we will be able to produce high quality contaminant free graphene grade material.

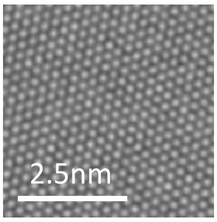

Figure 1a

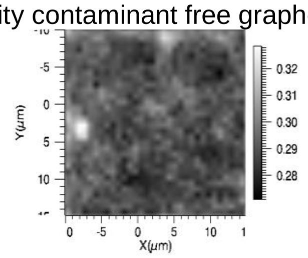

Figure 1b

Figure 1: a) Low-pass filter atomic resolution TEM images of graphene grown on Pt b) Raman mapping of a transferred graphene /SiO_2 by electro-chemistry method on 25x25µm.

References

[1] Ren, W., Cheng, H-M. Nature Nanotechnology, **9** (2014) 726-730
[2] Kim, J., Park H., Hannon, J.B., Bedell, S.W, Fogel, K., Devendra, K.S, Dimitrakopoulos, C. Science **342** (2013), 833-836
[3] Gao, L., Ren, W., Xu, H., Jin, L., Wang, Z., Ma, T. , Ma, L-P, Zhang, Z., Fu, Q., Peng, L-M, Bao, X., Cheng, H-M. Nature Communications, (2012), 3-7
[4] Ferrari, A. C. (2007) Raman spectroscopy of graphene and graphite: Disorder, electron–phonon coupling, doping and nonadiabatic effects, Solid State Commun, **Vol 143**, 47-57