Synthesis of Graphene on dielectric substrates using a modified filtered vacuum arc system

Helge Lux[1], Peter Siemroth[2], Sigurd Schrader[1]

[1] Technical University of Applied Sciences Wildau, Bahnhofstraße 1, 15745 Wildau, Germany
[2] Arc Precision GmbH, Bahnhofstraße 1 / Halle VII, 15745 Wildau, Germany

Contact Email: lux@th-wildau.de

Abstract

Here we present a reliable process to deposit graphene directly on silicon oxide, quartz, and mica (muscovite) using a solid carbon source. The process uses a pulsed filtered vacuum arc system to deposit a small but well defined amount of carbon homogeneously on heated substrates. The substrates are tilted with respect to the particle beam and a noble gas provides an inert atmosphere.
To prevent the buildup of agglomerations during the coating process a filtered arc system is used. Filtered arc evaporators produce a nearly droplet-free plasma stream of ionized atoms with particle energies of some tens of eV. By this way, carbon atoms will slightly be implanted and fixed at their place of arrival. Consequently, they cannot move over the surface and there cannot grow islands as it normally accrues with atoms or molecules of thermal energies.
In the present system, a pulsed filtered vacuum arc system is used to deposit a precisely defined amount of carbon atoms, needed to produce a full covered graphene layer. The Raman spectrum is dominated by the characteristic peaks “D”, “G”, and “2D” which are the typical signatures of sp^2 hybridized graphitic carbon (Figure 1, blue line).
The 2D peak (Figure 2) is split into four components: $2D_{1B}$, $2D_{1A}$, $2D_{2A}$, $2D_{2B}$. This is characteristic for multilayer graphene between two and five layers [1]. The position of the 2D-peak at 2700 cm^{-1} is shifted to a higher wavenumber as expected for few-layer graphene on silicon oxide [1,2].
The homogeneity of the graphene is shown by measuring the intensity of the 2D band over an area of (100 µm x 100 µm). The resulting false color picture shows neither holes nor any partial inhomogeneity (Figure 3, insert).
The best carbon layers have a surface resistance of $3 \cdot 10^3\ \Omega_{\square}$, measured by means of a 4-wire van-der-Pauw arrangement. The specific resistivity is found to be 1.5 µΩcm, and is independent on the number of layers
The filtered vacuum arc technology provides a completely metal free process for the graphene fabrication on insulating substrates. It can be used as a stable, large area graphene production, which is compatible to established CMOS and other semiconductor fabrication.

References

[1] A. C. Ferrari, J. C. Meyer, V. Scardaci, C. Casiraghi, M. Lazzeri, F. Mauri, S. Piscanec, D. Jiang, K. S. Novoselov, S. Roth and A. K. Geim, Raman Spectrum of Graphene and Graphene Layers, PHYSICAL REVIEW LETTERS, 97, (2006)

[2]Ying ying Wang, Zhen hua Ni, Ting Yu, Ze Xiang Shen, Hao min Wang, Yi hong Wu, Wei Chen and Andrew Thye Shen Wee, Raman Studies of Monolayer Graphene: The Substrate Effect, J. Phys. Chem. C, 112, pp.10637–10640 (2008)

Figures

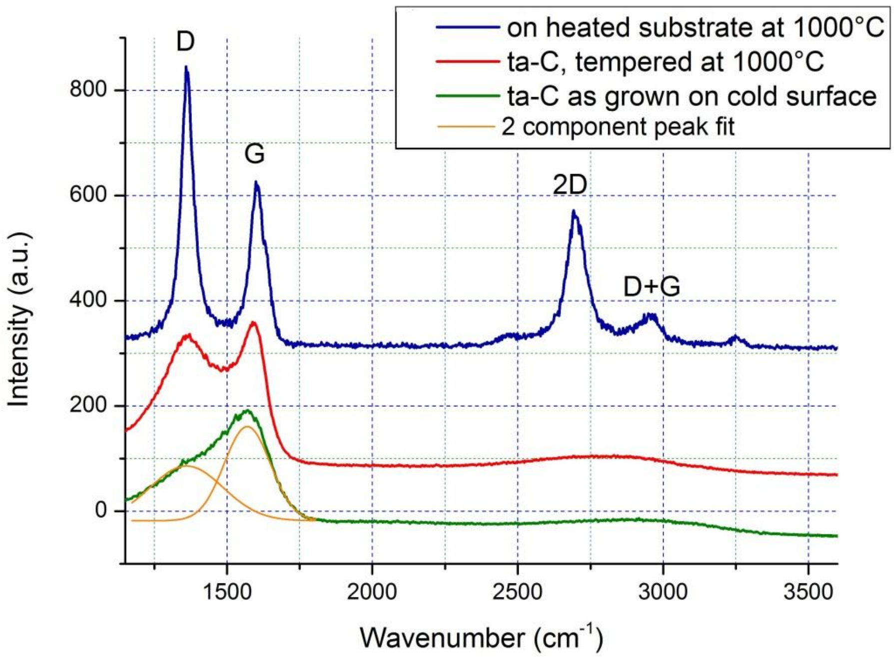

Figure 1: *Comparison of Raman spectra of different carbon layers. Conventional ta-C layer (green) split into its 2 components "D" and "G" (orange line); Annealed ta-C layer on quartz (red line); graphene, deposited on heated quartz (blue line).*

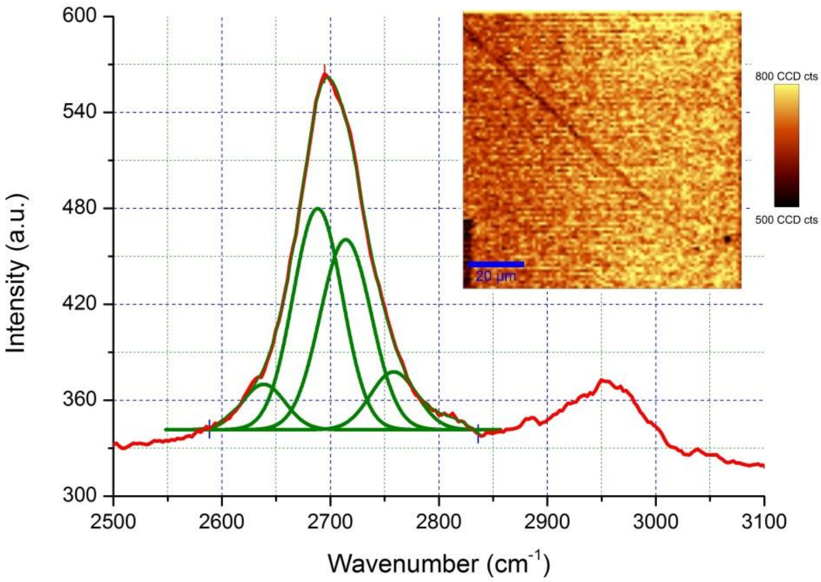

Figure2: *2D-Peak of graphene split in four components, insert: Large area scan of 2D-intensity (100 µm x100 µm)*