Synthesis of Graphene-based transparent and conductive films on insulators using a modified high current arc evaporation process

H. Lux[1], C. Villringer[1], P. Siemroth[2], M. Casalboni[3], A. Sgarlata[4], M.A. Schubert[5], S. Schrader[1]

[1]Technical University of Applied Sciences Wildau, Hochschulring 1, 15745 Wildau, Germany
[2]Arc Precision GmbH, Schwartzkopffstraße 2, 15745 Wildau, Germany
[3]University of Roma - Tor Vergata, Department of Industrial Engineering, Via del Politecnico, 1 00133 Roma, Italy
[4]University of Roma - Tor Vergata, Department of Physics, Via della Ricerca Scientifica, 1 00133 Roma, Italy
[5]IHP Innovations for High Performance Microelectronics, Im Technologiepark 25, 15236 Frankfurt (Oder), Germany

Contact Mail: lux@th-wildau.de

Abstract

We present a simple and stable approach to deposit graphene-containing transparent and conductive carbon coatings directly on arbitrary insulating substrates (fused quartz, sapphire, boron crone glass) using a solid carbon source. In contrast to established CVD-processes, we do not need any catalytic metal substrate or coating. The current process uses a pulsed filtered high current arc evaporation (Φ-HCA) to deposit a small but well defined amount of carbon homogeneously on heated substrates. To from graphene-containing coatings instead of ta:C (tetrahedral amorphous carbon) as it normally occurs by using such a carbon source, the substrate is heated and the chamber is filled with different functional and/or inert gases. In contrast to the processes reported in literature [1,2], the complex deposition parameters, which are a result of a systematic optimization process, are able to effectively avoid the formation of perpendicular grown graphitic carbon. TEM measurements show a predominantly flat lying graphitic structure with a high portion of graphene flakes. This result is in contrast to the well-known thermal modification (annealing) of ta:C, where the sp^3- content of the coatings is quite constant, resulting in a strongly reduced resistivity [3,4,5]. Consequently, our coatings provide a specific resistivity, which is more than 4 orders of magnitude lower. Furthermore, the electrical properties (sheet resistance, charge carrier mobility) are comparable to the published values of reduced Graphene oxide. The coatings has been characterized using confocal Raman microscopy (Figure 1a), TEM, STM (Figure 1b), AFM, Hall measurements, Spectral photometry (transmission, reflection), and Spectral ellipsometry. The best carbon layers have a surface resistance of 5k$\Omega_{\square}$, with an absorption of only 12%. The filtered high current arc evaporation provides a completely metal free process for the fabrication of transparent and conductive graphene-containing carbon coatings on insulating substrates. It can be used as a stable, large area production, which can be compatible to established CMOS and other semiconductor fabrication.

References

[1] Y. Yin et al, Nuclear Instruments and Methods in Physics Research B 119 (1996)
[2] N.A. Marks et al., APPLIED PHYSICS LETTERS 89 (2006)
[3] A. Ilie et al., J. Appl. Phys. 90, 2024 (2001)
[4] A.C. Ferrari et al., Journal of Applied Physics 85 (1999)
[5] D.S. Grierson et al., Journal of Applied Physics 107 (2010)

Figures

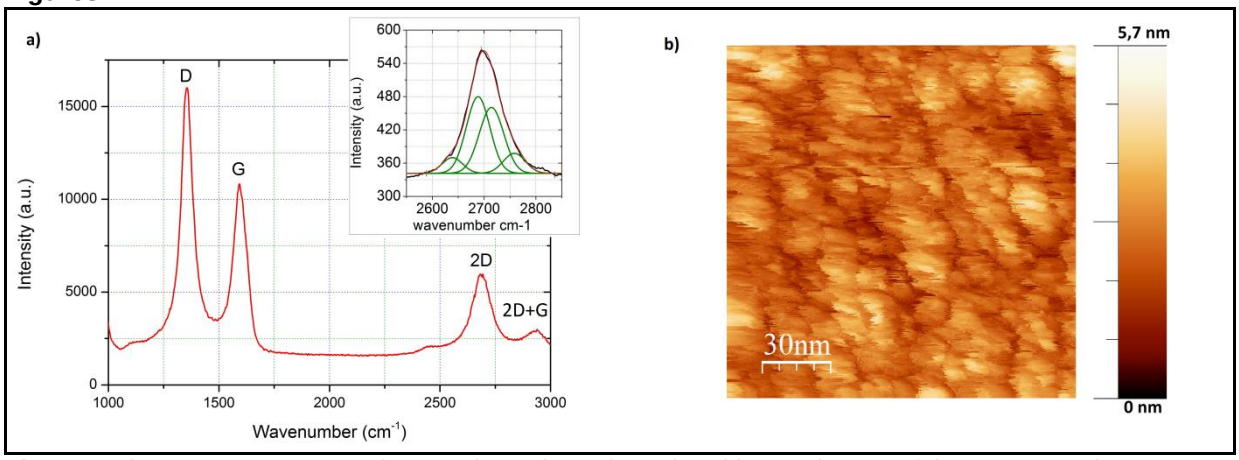

Figure1: a) Raman Spectrum of a Graphene-based coating, b) STM image of the same coating