Graphene formation on SiC (0001) surface steps by CVD process

K. Grodecki[1,2], R. Bozek[2], A. Wysmolek[2], R. Stepniewski[2], W. Strupinski[1], and J. M. Baranowski[1,2]

[1] Institute of Electronic Materials Technology, Wolczynska 133, 01-919 Warsaw, POLAND
[2] Institute of Experimental Physics, Physics Department University of Warsaw, Hoza 69, 00-891 Warsaw, POLAND

Understanding of formation processes of epitaxial graphene as well as its interaction with SiC substrates is still very limited. In this communication we show that new and valuable information about physical properties of epitaxial graphene can be obtained from mutual studies including Atomic Force Microscopy (AFM), Scanning Kelvin Probe Microscopy (SKPM) and confocal micro-Raman spectroscopy, with submicron spatial resolution. Combination of these techniques allows for direct comparison of graphene morphology, thickness as well as strain state on terraces, step edges and macrosteps present at SiC substrates. Here we focus our attention on the graphene structures grown by Chemical Vapor Deposition (CVD) on 4H-SiC(0001) substrates, using propane as a source of carbon [1].

Typical AFM images obtained for graphene grown on 4H-SiC(0001) on-axis substrates show well resolved, nearly flat terraces of width of about 1 – 10 □m separated by macrosteps (typically 5nm high). Micro-Raman experiments performed on the same samples show that graphene on the terraces is very uniform and almost unstrained. The average position of Raman 2D line in these regions is between 2690 –2700cm^{-1}, whereas the half-width of the 2D line is of about 35-40cm^{-1}, what indicates a good quality of the graphene. On the other hand the 2D line is blue shifted to 2730cm^{-1} on the step edges, what indicates strong compressive strained in these regions. Interestingly, the integrated intensity of the 2D line on the step edges is about twice larger than on terraces, what would be interpreted in terms of formation of thicker graphen. This result is consistent with the SKPM measurements which revealed different electric potential on the flat terraces and the step edges. These results are closely related to the observation of erosion of step front observed by AFM. The erosion spreads at distance 200-300 nm from the step edge and leads to the formation of sleeplike structures of 1nm high. In the eroded regions wrinkles are observed, what also indicates formation of thicker graphene multilayer.

In summary, our results strongly suggest that in the CVD technique, similarly to the sublimation method, step bunching plays important role in the graphene formation. Apparently, graphene nucleates at the SiC macrosteps edges and grow laterally over the terraces regions above steps.

**This work has been partially supported by Polish Ministry of Science and Higher Education projects 670/N- ESF-EPI/2010/0 and 671/N- ESF-EPI/2010/0 within the EuroGRAPHENE programme «EPIGRAT»of the European Science Foundation.*

[1] *Graphene Epitaxy by Chemical Vapor Deposition on SiC*, W. Strupinski, K. Grodecki; A.Wysmolek, R. Stepniewski, T. Szkopek, P. E. Gaskel, A. Gruneis, D. Haberer., R. Bozek, J. Krupka, and J. M. Baranowski
Nano Letters 1, 1786 (2011)