(Graphene 2012 Extended abstract format: 2 pages max including figures and references. Font: Arial 10, use line spacing single. Please follow the model below.)

Self-Assembled Graphene/Graphene Oxide Nanostructures Formed Through Photocatalitic Oxidation.

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Graphene-based layer heterostructures have a great potential for high-performance electronic devices due to its fascinating electrical, optical, thermal and mechanical properties. Graphene/graphene oxide (G/GO) structure is one of the promising structures for the formation of a resistive memory based on graphene [1, 2]. One of the most simple and cheap oxidation methods of graphene is the photocatalitic process in which a sufficiently wide-band-gap semiconductor and UV-irradiation are used for the photocatalitic generation of active oxygen. ZnO is good candidate as important functional material, possessing a direct wide band gap of 3,3 eV. ZnO nanoparticles and nanorods can be synthesized by a simple inexpensive method from solution. This method ensures the process scalability and cost efficiency.

In this work, the local modification of graphene by ZnO nanocrystals under UV-light was investigated. This approach allows forming the self-assembled G/GO lateral nanostructures, which demonstrate the effect of the resistive switching.

In the photocatalitic process we used spherical nanoparticles with diameter of 15 nm. Graphene was synthesized by chemical vapor deposition (CVD) on Cu foil and transferred to a Si/SiO_2 substrate. Distance between the ZnO nanoparticles spin-coated on graphene varied from a few nanometers that allowed to create the lateral G/GO nanostructures by photooxidation of graphene around the nanoparticles during UV-irradiation. After irradiation the ZnO nanoparticles were dissolved in dilute HCl (0,1M).

The prepared G/ZnO structure on a Si/SiO_2 substrate with indium top electrodes was investigated. The distance between indium contacts was 1.5 cm. The measured I-V curves of this structure showed that after the photocatalitic process the conductivity of graphene decreased by 2 orders (100 times). Moreover before irradiation I-V curve had a linear behavior (fig.1-left) while after irradiation I-V curve showed non-linear behavior (fig.1-right) which indicates the formation of the band gap. After the forming process (V=+5V) the structure showed the reliable and reproducible unipolar resistive switching. The ratio of the on and off currents was about 10 (fig.2). We suppose that during UV-irradiation of the G/ZnO structure, graphene was decorated by epoxy, hydroxyl, carbonyl groups supplied by the process of photodecomposition of water from the surrounding atmosphere. The observed resistive switching of the heterostructure could be due to the mobility of the functional groups [1].

Raman spectra of the graphene-based structure were obtained before, and after UV-light irradiation (fig.3). G/D ratio mapping of the CVD- graphene before photocatalitic process founds bi-,trilayer graphene. After UV-irradiation as we can see from fig.3 the ratio I(G')/I(G) increased. We assume that this increase is associated with decomposition of one layer of graphene in some local areas. Increasing the intensity of the D-peak after irradiation indicates the oxidation of graphene. The mechanisms and the nature of the observed effects are discussed.

References

[1] Gennady N. Panin, Olesya O. Kapitanova, Sang Wuk Lee, Andrey N. Baranov, and Tae Won Kang, Resistive Switching in Al/Graphene Oxide/Al Structure, Japanese Journal of Applied Physics, **50** (2011) 070110-1.
[2] O. O. Kapitanova, G. N. Panin, A. N. Baranov, and T. W. Kang, Synthesis and Properties of Graphene Oxide/Graphene Nanostructures, J. Kor. Phys. Soc., 60 (2012)1789-1793.

Figures

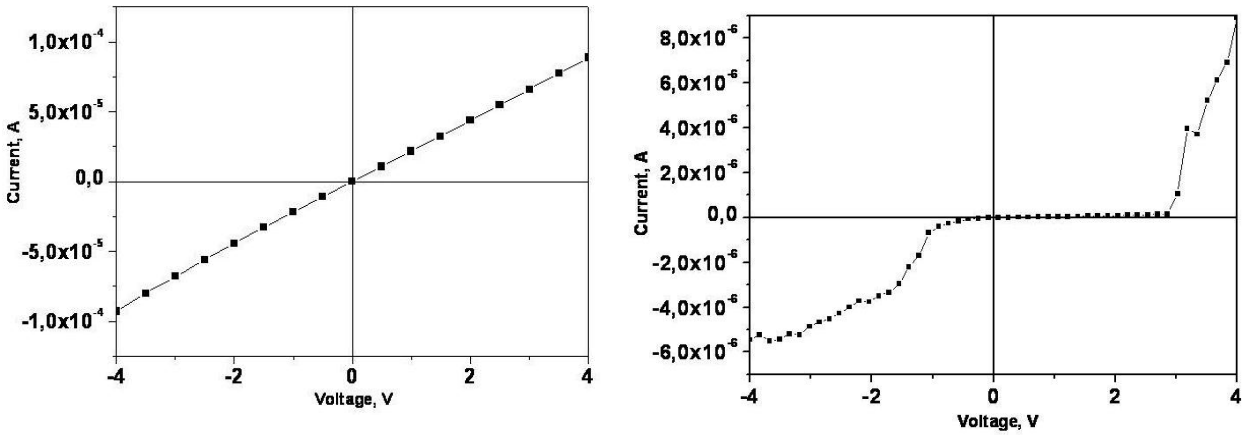

Figure 1. I-V curves: before UV - irradiation of graphene (left) and after (right).

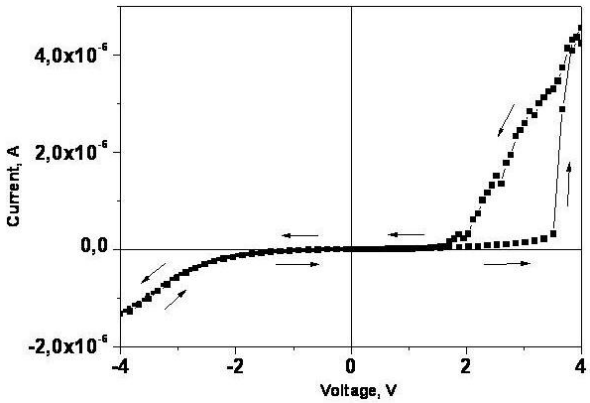

Figure 2. Resistive switching of graphene-based structure after UV - irradiation and pre-formation at +5V.

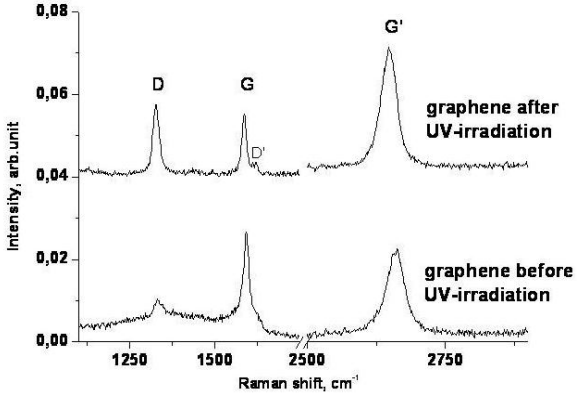

Figure 3. Raman spectra of graphene before and after UV- irradiation.