The characterization of resistive switching in graphene oxide layer prepared by inkjet printing

M. Rogala[1,2], **P. J. Kowalczyk[1]**, W. Kozlowski[1], A. Busiakiewicz[1], I. Wlasny[1], S. Pawlowski[1], G. Dobinski[1], M. Smolny[1], L. Lipinska[3], R. Kozinski[3], K. Librant[3], P. Dabrowski[3], J.M. Baranowski[3], K. Szot[2], Z. Klusek[1]

[1] Department of Solid State Physics, Faculty of Physics and Applied Informatics, University of Lodz, Pomorska 149/153, 90-236 Lodz, Poland
[2] Peter Grünberg Institut & JARA-FIT, Forschungszentrum Jülich, 52425 Jülich, Germany
[3] Institute of Electronic Materials Technology, Wolczynska 133, 01-919 Warsaw, Poland

pkowa@uni.lodz.pl

Abstract

Resistive switching (RS) processes recently discovered in graphene oxide (GO) [1] shows a new way of non-volatile data storage in flexible solid state devices. The principles of operation of novel resistive random-access memory (ReRAM) consist of electrically inducted reversible changes of material resistivity between well distinguishable low resistance (ON) and high resistance (OFF) states [2]. The RS is closely related to the memristance according to "memory resistor" (memristor) which is a forth passive two terminal electrical component.

We will discuss the conditions which must be met in order to achieve the effect of changes of resistance in GO. In our experiments we used graphene oxide produced using modified Hummers method. The GO thin films of various thicknesses (20 – 100 nm) were inkjet printed on a silicon substrate covered with platinum, which was the flat bottom electrode. The top electrode, which was in contact with GO film, was the Pt covered tip of atomic force microscope (AFM). Environmentally controlled AFM setup was used, which allows for investigations in vacuum, different gases and control of humidity in the range of up to 70%RH. The use of inert electrode material in combination with very low contact area of the top electrode allows us to analyse the influence of the environmental factors on resistive switching processes occurring in GO.

By the use of atomic force microscope we were able to modify the electrical conductivity in nano-regions of GO thin film between ON and OFF states. The observed resistive switching has bipolar character, which is related to the asymmetry of the experimental setup (top of the sample is exposed to the environment which can be controlled during the experiment). We will present how the composition of the atmosphere around GO influences the strength of the RS effect. We will also focus on the dependence between the effectiveness of the electrical modification of the material and the thickness of GO film. We will discuss observed reduction/oxidation processes occurring in graphene oxide layer in terms of its spatial distribution and their consequences on the morphology changes of the thin film. Results of our investigations have a direct connection to the challenges the industry will face when GO will be used to construct ReRAM devices with the desired parameters.

This work is supported by the National Science Centre under project DEC-2012/05/B/ST5/00354 and the National Centre for Research and Development under the project GRAF-TECH/NCBR/15/25/2013.

References

[1] C.L. He et al., Appl. Phys. Lett. **95** (2009) 232101.
[2] K. Szot, M. Rogala, W. Speier, Z. Klusek, A. Besmehn, R. Waser, Nanotechnology **22** (2011) 254001.