The resistive switching effect in the composite films based on fluorinated graphene

Ivanov A.I. [1], Kotin I. A. [1] , Antonova I. V. [1,2]

[1] *A.V. Rzhanov Institute of Semiconductor Physics, Russian Academy of Sciences, Siberian Branch, Acad. Lavrentiev Avenue 13, Novosibirsk 630090, Russia;*
[2] *Novosibirsk State Technical University, 630073, Novosibirsk, K. Marx Avenue 20, Novosibirsk, Russia;*

Fluorinated graphene (FG) is the most stable derivative of graphene, which makes it a promising material for applications. Recently, we have developed a technology of graphene fluorination in aqueous solution of hydrofluoric acid, allowed to produce fluorinated graphene with a controlled degree of fluorination. The current-voltage characteristics for films of this material were found to demonstrate resistive switching [1,2]. The advantage of resistive memory based on fluorinated graphene films are stability of the material and the ability to create films on rigid and flexible substrates at room temperature. In the present study, we considered the resistive switching phenomenon observed for the two types of structures based on partially fluorinated graphene with polyvinyl alcohol (PVA) or nanoparticles of VO_x (mainly V_2O_5) [3].

In the first case, the structures were prepared by printing of partially fluorinated graphene (PFG) ink onto the surface of PVA/Si substrate. Schematic representation of this structure and SEM images are shown in Fig.1a and Fig.1b respectively. In the process of printing, FG ink dissolve the water-soluble PVA film. It leads to the formation PVA foam covered by PFG structure, see Fig.1b. The current-voltage characteristics of these structures are shown a stable resistive switching effect with resistance change up to one - two orders of magnitude [4]. The switching mechanism was proposed for these structures due to studying the carrier transport in films and trap recharging kinetics. In the second case, composite suspensions containing FG flakes and nanoparticles of VO_x are considered. Stable resistive switching effect up to eight orders of magnitude is observed for these crossbar structures (Fig.1c). To understand the role of nanoparticles of VO_x, its size and concentration is being varied in the films of FG. The voltage pulse duration times sufficient for the transition of the structure to a low resistive state are ranged from 100 ns to 10 μs for FG-PVA and from 1 μs to 10 μs for FG-VO_x.

The obtained structures are promising development of non-volatile memory cells in the field of flexible and 2D printed electronics.

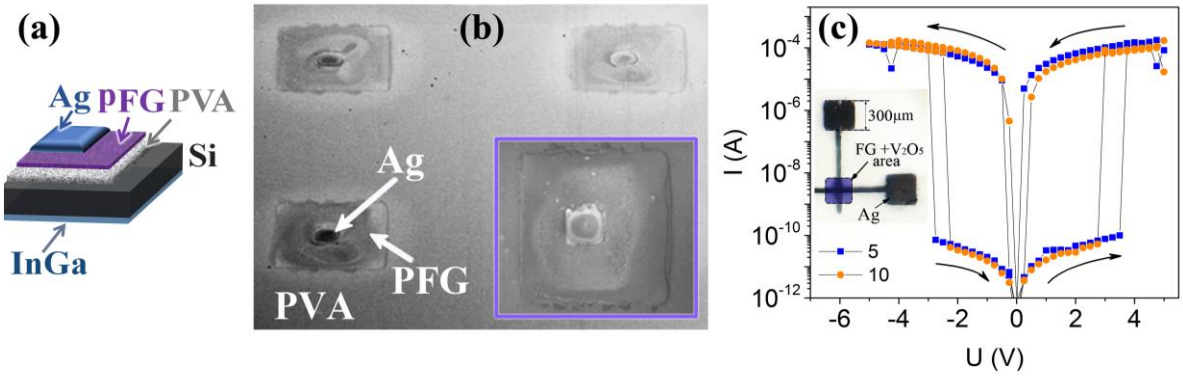

Fig. 1. Resistive switching effect in films based on fluorinated graphene: (a) the schematic representation of structure based on PFG-PVA film, (b) SEM images of printed Ag / FG / PVA structures. The size of the FG structures is 300x300 μm, the size of the Ag contact pads is 70x70 μm. In the lower row there are no contact pads. SEM image were made at an angle of 55°, and the insert in the lower right corner was taken without tilting of the structure, (c) current-voltage characteristics of crossbar structure based on FG - VO_x composite, the optical image of structure is shown as an insert.

[1] A.I. Ivanov et al. *Physical Chemistry Chemical Physics*. 2017. - Vol.19. - P. 19010-19020.
[2] A.I. Ivanov at al. *Semiconductors*. 2017. V. 51, № 10. P. 1306-1312.
[3] A.I. Ivanov at al. *J Material Sci. Eng*. 2017. V. 6, №. 379. P. 2169-0022.1000379.
[4] A.I. Ivanov at al. – in press.