Scaling down resistive switching effect in polymer materials and resistive memory based on this effect

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Nowadays exists great demand on constructing new memory devices, which could overcome limitations of already existing devices and be fast-operating, non-volatile, compact and cheap. One of possible solutions is memory based on the effect of resistive switching (RRAM). The main advantage of RRAM based on polymer materials is an easy technology- there is no need to use high temperatures or ultra high vacuum, such methods as coating or printing can be used.

In our research we studied polymer materials polyvinylchloride, polystyrene, polycarbonate with and without addition of metal micro particles, plasticizers and photosensitizing dyes from phtalocyanines. Contacts were made from Ag, Cu, glass with ITO and lithographically deposited golden contacts with various geometry. Distances between contacts in coplanar geometry varied from 0.7mm to 7 mkm, in sandwich geometry-from 1 mm to 70 nm. Resistive switches were obtained at temperatures varying from 4.2 K to room temperatures. Switching times were less than 10 ns and retention time of “ON” and “OFF” states exceeds 6 months.

Before were studied switching characteristics of polymer materials at macro scales with distances between contacts 0.05-1 cm in coplanar geometry and the thickness of working material 50 mkm-0.2 cm for samples in sandwich geometry [1]. The target of current research was to define switching characteristics at micro scales with distances in coplanar geometry varying from 7 to 250 mkm and minimum thickness of 70 nm for sandwich samples. Coplanar samples were made from polymer and composite materials: with addition of different metal micro particles such as Al, Ag, Zn, Cu to polymer matrix. Sandwich samples were produced by vacuum deposition. Switches were observed at both geometries. Conducting state resistance R_{ON} was less than 10^5 Ohm and low conducting state resistance R_{OFF} exceeded 10^6 Ohm. Electrical fields, needed for switching samples from low conducting to high conducting state do not exceed 10^3 V/cm for composite materials and $4*10^4$ V/cm for other materials. These values are less than the same for macro samples. At meantime current densities for micro samples $2*10^{-2}$ A/mm^2 exceeded the values for macro samples $8*10^{-3}$ A/mm^2. In case of filamentary switching mechanism these results mean higher current conductivity in conducting filaments responsible for high conductivity in ON state. Switching times are less than 10 ns and retention time of “ON” and “OFF” states exceeds 6 months, number of switches is not less than 10 million.

Results of the investigation of resistive switches in polymer materials show wide perspectives for building efficient, non-volatile, fast and easy to produce cheap memory devices.

[1] Kotova M.S., Dronov M.A., Belogorokhov I.A.// Naychno-technicheskie vedomosti SPbGPU 2012. **2.** P. 37-41