Photoinduced resistive switches in hybrid organic structures including colloidal CdSe nanocrystals

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Abstract

Development of composite structures is an important direction in organic electronics. It was shown in our previous work that composite materials have high potential for memory applications [1]. The operation principles of resistive memory presume an ability of the system to switch between at least two states "ON" and "OFF" with different resistances (resistive switches RS). Embedding metal particles (linear size _˜5 μm) into isolating in pristine state polymer results in RS speed less than 15 ns, non-volatile characteristics, on/off ratio over 2 orders of magnitude, switching electric field below breakdown values, number of rewriting cycles 105 or higher1. Samples can be fully fabricated by printing techniques, and we demonstrated that there are no significant differences in their performance compared to samples on hard substrates [3].

For practical application further investigations of downsize scaling impact are required. Replacing metal micro particles with organic photoactive semiconductor particles of various sizes (1.3-2.3 nm in length and 0.3-0.8 nm height) allowed us to control switching voltage using external light source [4]. Introduction of inorganic nanoparticles (NP) can lead to increase in photoresponse and stability of RS in composite structures due to charge transport between NP and organic media.

In this work we observed RS in composite structures consisting of polystyrene matrix with incorporation of colloidal nanoplates CdSe, tert-butyl-substituted lutetium diphthalocyanine, hexadecachloro-substituted lutetium triphthalocyanine and other dyes. We obtained similar results for coplanar and sandwich contact geometries. I-V curve in "OFF" state is attributed to Richardson-Schottky or Poole-Frenkel conduction mechanisms. In "ON" state I-V curve can be approximated by linear omic dependence, temperature dependence of conductivity demonstrates metallic type. RS is dependent on external illumination. Photoconductivity spectrum for composite structures demonstrates the same local maximums and minimums as absorption spectrum of NP that confirms charge transport between NP and organic media. We demonstrated that incorporation of CdSe nanoplates into organic matrix provides a promising material for construction of high density and efficient memory. This work was supported by RFBR (project nb 16-07-00961, 15-03-05890, 16-33-60005).

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