Metallic conductivity in a polyamidine film

A. N. Ionov, [1] M.N.Nikolaeva, [1,2 *] R. Rentzsch [3]
[1] *Ioffe Physico-Technical Institute, 194021 St. Petersburg, Russia,* [2] *Institute of Macromolecular Compounds, 199004 St. Petersburg, Russia,* [3] *Institut für Experimentalphysik, Freie Universität Berlin, 14195 Berlin, Germany*

The main aim of molecular-scale electronics technology is to use molecular scale components such as single molecules, small numbers of molecules, nanoparticles, nanoscale metallic wires, nanotubes, etc., as electronic components. In this connection certain interest presents a high conductivity which is observed in some polymer's films placed between metallic electrodes at film thickness no higher than 1-2 micron [1and references therein]. If the electrodes undergo a transition into the superconducting state, a supercurrent flows through the polymer film. In this case Josephson voltage oscillations have been obtained which behave like a great number of Josephson contacts [1]. Another characteristic was that the conductivity effect was not observed if the contact area was too small, diameter less about 100 nm^2 [2]. In accordance with model [3] the electrification effect plays the crucial role in switching to the high conductive state [4]. Inside the forbidden gap of the polymers, energy states with energy close to the Fermi level of metals are formed as a result of atomic and electronic relaxation processes due to electrification [3].

In the following, we focused our investigations on the temperature dependence of conductivity for polyamidine films with different contact areas between electrode and polymer surface. At investigating simultaneously a surface topography of polymer film and a current distribution by atomic force microscope at room temperature, we obtained that some places of polymer film have reversible switching to the high conductive state with electrical field strength less than the breakdown field (10^6 V/cm) whereas the other ones have metallic conductivity with Ohmic characteristic. Conductivity phenomena exhibit a strong dependence on the contact area between polymer surface and metallic electrode. We consider that the high conductive state of this particular polymer is a collective phenomenon of some critical number of polymer chains.

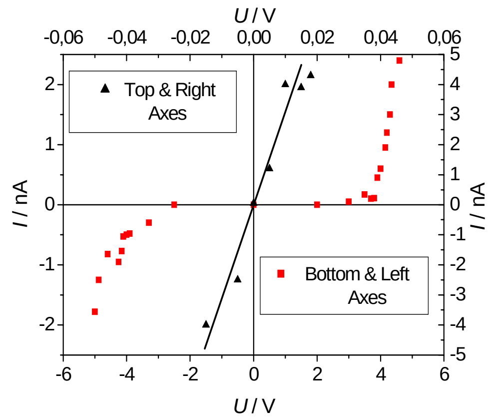

Fig. 1. Reversible On/Off current switching and Ohm's law behaviour at different points of the polymer surface. In both cases the CVC scanning time was about 1 s.

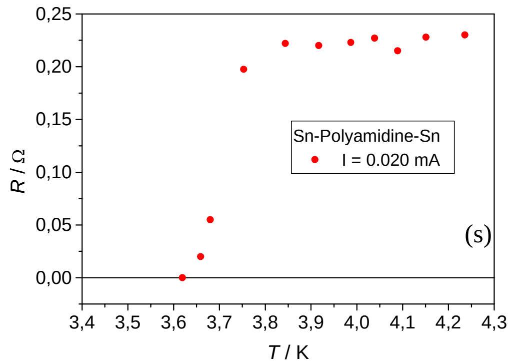

Fig. 2. Temperature dependence of the resistance of a Sn-Polymer –Sn sandwich of thickness 2 µm (placed inside a dielectric spacer ring of inner diameter of about 360 µm). Sn undergoes to the superconducting state at T = 3.72 K.

The behavior of $R(T)$ dependence of the polyamidine film placed in a smaller ring spacer with an inner diameter of about 3-4 µm and with the same thickness as before is as follows: i) the absolute value of the resistance is larger than that in fig. 2 by a factor of 10^2; ii) the resistance starts to increase at $T <$ 3.0 K.

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[*] Email: ionov@ioffe.tuch.ru