

Transport and Relaxation of Charge in Organic-Inorganic Nanocomposites

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Hybrid nanocomposites on the base of conjugated polymers reinforced with inorganic nanoparticles of different nature are in the focus of increased attention as composite materials for sensing and optoelectronics applications [1–3]. Incorporation of ZnO and silicon nanoclusters give a possibility to use electrochemical properties of conjugated polymers, size effects and large area surface of semiconductor nanoparticles. Comprehensive study of the electrical parameters of organic-inorganic nanocomposites improves functionality and extends prospect of practical application of the hybrid materials.

Present work focuses on the studying the processes of charge transport in nanocomposites based on poly(3,4-ethylenedioxythiophene) abbreviated hereafter as PEDOT and mixture of porous silicon (PS) and ZnO nanoparticles for sensor electronics. PEDOT–PS–ZnO hybrid films were characterized by scanning electron microscopy. The electrical properties of the obtained nanocomposites were investigated by means impedance spectroscopy in the frequency range of 25 Hz – 1 MHz and thermally stimulated depolarization (TSD) spectroscopy.

Electrical resistance and capacitance of the PEDOT–PS–ZnO composites depend on the composition. Increasing of content of ZnO nanoparticles caused the rise in the internal resistance of the PEDOT:PSS–PS–ZnO films from 20 to 70 MOhm. The complex frequency dependence of the impedance of hybrid films can be caused by the features of transport and relaxation of charges in disordered systems. Studies of the relaxation processes in the hybrid nanocomposites were performed using TSD spectroscopy in 80–325 K temperature range. In the case of disordered systems the trap levels are distributed quasi-continuously on the activation energy. To determine the activation energy of electrically active defects in experimental films, the temperature dependencies of the depolarization current have been measured. The analysis of the TSD spectra and the calculation of the density of states energy distribution suggests that the groups of trap levels, with differences in nature and activation energies in the ranges of 0.2–0.4 and 0.5–0.7 eV are present. Such localized electron states influence the charge transport in the PEDOT–PS–ZnO composites.

We have found experimentally that the electrical characteristics of our composite films are strongly dependent on the surrounding atmosphere. In particular, increasing relative humidity results in significant decrease of the electrical resistance of the PEDOT–PS–ZnO hybrid films. The response time of the sensory elements to changing of water vapour concentration is about 20 s. The combination of the porous silicon and zinc oxide nanoparticles provides an increasing of surface area of the sensors and their high sensitivity to water molecules.

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- [2] E. Holder, N. Tessler, A.L. Rogach, Hybrid nanocomposite materials with organic and inorganic components for optoelectronic devices, *Journal of Materials Chemistry* **18** (2008) 1064.